U. S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

Date: January 15, 2013
Chemical: Ethanaminium (2,4-D choline salt)
PC Code: 051505
DP Barcodes: 400223, 400230, 400234, 400237, 405028, 405812
DECISION: 447951, 442244, 457755, 456480
MEMORANDUM

SUBJECT: **EFED Environmental Risk Assessment of Proposed Label for Enlist (2,4-D Choline Salt), New Uses on Soybean with DAS 68416-4 (2,4-D Tolerant) and Enlist (2,4-D + Glyphosate Tolerant) Corn and Field Corn**

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The Environmental Fate and Effects Division (EFED) has assessed the ecological risks to listed and non-listed species associated with the proposed new uses of 2,4-D choline salt on herbicide-tolerant corn and soybean.

No direct risks from the proposed applications of 2,4-D choline salt to herbicide-tolerant corn and soybeans were identified for the following:

- Birds (chronic)
- Aquatic plants
- Freshwater fish (acute and chronic)

- Estuarine/marinefish (acute and chronic)
- Freshwater invertebrates (acute and chronic)
- Estuarine/marine invertebrates (acute and chronic)
- Aquatic plants
- Terrestrial insects

There was insufficient information to determine if the following groups are at direct risk from the proposed new uses of 2,4-D choline salt:
- Mammals (acute and chronic)
- Birds, reptiles, terrestrial-phase amphibians (acute)
- Terrestrial plants

In addition, there was insufficient information for all taxa to determine if indirect effects are expected because of potential dependencies (e.g., food, shelter, habitat) on species that are directly affected. Information, such as biological distribution, species biology, spray drift properties specific to the 2,4-D choline formulations, and mitigation efforts in regions where the pesticide is used, could be used to reduce the uncertainty regarding potential direct and indirect effects.

A spray drift analysis using the AIXR 11004 nozzle and the GF2726 formulation indicated that buffers of 202 feet would reduce risk quotients for birds (acute), mammals (acute and chronic), and terrestrial plants below the Agency's levels of concern. This buffer is only achieved through the combination of the AIXR 11004 nozzle and GF2726 formulation. The locations of the buffers would be dependent on species distribution, species biology, and any mitigation efforts proposed by the registrant.

The following major data gaps and uncertainties were identified in this assessment:
- Acute oral toxicity test for passerines (850.2100) is not available; data from bobwhite quail and mallard duck were used as surrogates.
- Estuarine/marine invertebrate chronic toxicity test (850.1350) is not available; an acute-to-chronic ratio based on freshwater invertebrates was applied.
- Terrestrial plant seedling emergence and vegetative vigor tests (850.4100, 850.4150) were not available for the 2,4-D choline salt/glyphosate formulation; data from other 2,4-D forms were used as surrogates. There is uncertainty as to whether they accurately represent the toxicity of a dual herbicide product to terrestrial plants.
- Vapor-phase effects data on terrestrial plants were limited in scientific soundness; conservative assumptions were made to characterize the risk to terrestrial plants from vapor-phase drift.

Key Uncertainties and Information Gaps

A number of ecological and fate uncertainties were identified. Table 1 lists several studies that could be used to address these uncertainties.

Table 1. Fate and Ecological Toxicity Data Gaps for 2,4-D Choline Salt

Guideline#	Data Gap	Justification
835.6100	Terrestrial Field Dissipation	To confirm the bridging strategy for the environmental fate behavior of 2,4-D choline salt to 2,4-D acid, a terrestrial field dissipation study would be needed.
850-6100	Analytical methods for soil and water	An environmental chemistry method(ECM) in soil and water would be used to support the terrestrial field dissipation study. An independently validated environmental chemistry method aswell as ECM in soil and water is necessary to evaluate the results of the terrestrial field dissipation study.
850.2100	Avian Oral Toxicity Test for Passerines	The CFR requires testing for one passerine species when a chemical is intended for outdoor use. The currentmethod of calculating a weight-adjusted LD_{50} using bobwhite quail or mallard duck data may over- or under-estimate risks to passerines because these birds may metabolize the chemical differently. This study has already been requested through the Problem Formulation of Registraton Review. A protocol for the study should be submitted to EPA for approval prior to study initiation.
850.4150	TerrestrialPlant Vegetative Vigor Test	The CFR requires typical end-use data for terrestrial plants. In the case of the new 2,4-D choline salt registrations, no information is available for the two 2,4-D choline salt formulations, nor the Enlist™ formulation, which is a mixture with glyphosate. For the 2,4-D choline salt-glyphosate formulation, it is anticipated that there could be additional toxicological effects (synergistic or additive) because of the presence of two herbicides. This could change the outcome of the assessment by yielding more sensitive toxicity values for terrestrial plants, thus modifying minimum buffer distances.
Non-guideline	TerrestrialPlant Vegetative Vigor Test with Vapor Phase Exposure	2,4-D is known to volatilize from the field and drift off site under certain environmental conditions. EFED evaluated a vapor-phase study on grapes, cotton, soybean, and tomato; however, the methodology did not include a control, did not measure growth/weight parameters, and was not well-aligned with the 850.4150 protocol. Open literature studies and field data from the vapor-flux study suggest 20% plant damage corresponds to significant reductions in yield. A vapor-phase study with vegetative vigor endpoints would confirm these conclusions At a minimum, grape and cotton should be tested as these were the most sensitive species in the submitted vapor-phase study.

Labeling Recommendations

According to the Label Review Manual, the following label statements are recommended for 2,4-D choline formulations for ground boom application (http://www.epa.gov/oppfead1/labeling/lrm/index.htm):

Application Instructions

A combination of AIXR 11004 spray nozzle, GF-2726 formulation, and appropriate pressure are required to be selected to provide ASABE Standard S571.1 droplet size category of coarse/very coarse ($D_{V0.5}$ of ≥ 439µm) or coarser. Directions from the equipment manufacturer or vendor, pesticide registrant or a test facility using a laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested at least annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated".

To add additional nozzles to the label, spray drift curves for the new nozzle and/or droplet spectrum information must document that the additional nozzle(s) is expected to perform similarly to the nozzles already specified on the label with the GF-2726 formulation.

Environmental Hazards

"This pesticide is toxic to birds, mammals, fish, and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate."

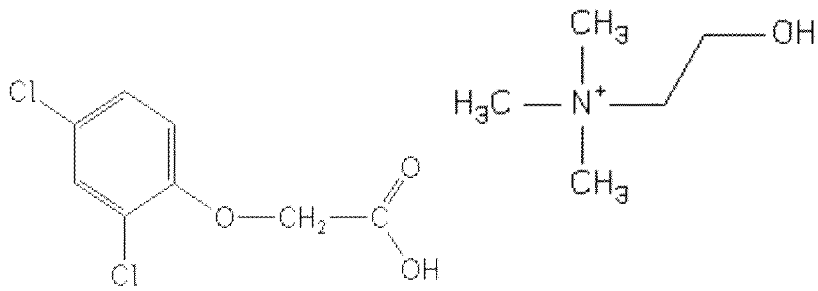
Groundwater Advisory

"2,4-D, an anion of 2,4-D choline is known to leach through soil into groundwater under certain conditions as a result of label use. This chemical may leach into groundwater if used in areas where soils are permeable, particularly where the water table is shallow."

Surface Water Label Advisories

"2,4-D from 2,4-D choline application may impact surface water quality through spray and runoff of rain water. This product has a high potential for runoff for several months or more after application. Poorly draining soils and soils with shallow water tables are more prone to produce runoff that contains this product. A level, well maintained vegetative buffer strip between areas to which this product is applied and surface water features such as ponds, streams, and springs will reduce the potential for contamination of water from rainfall-runoff. Runoff of this product will be reduced by avoiding applications when rainfall is forecasted to occur within 48 hours."

Ecological Risk Assessment for the Section 3 New Use Registration of 2,4-D Choline Salt on Soybean with DAS 68416-4 (2,4-D Tolerant) and 2,4-D + Glyphosate Tolerant Corn and Field Corn



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Acknowledgements

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1. Executive Summary

2,4-D choline salt is an herbicide in the phenoxy or phenoxyacetic acid family that is used preplant, preemergence and postemergence for selective control of broadleaf weeds. It is currently registered on a number of crops including: sugarcane, rice, pome fruits, stone fruits, conventional corn and soybeans, fallow land, turf, and tree and brush control. Dow Agrosciences LLC, the manufacturer and registrant of 2,4-D choline salt, submitted an application to the U.S. Environmental Protection Agency (EPA) to add the following uses to the 2,4-D choline salt label: 1) Enlist corn and field corn (containing DAS 68416-4 trait), and 2) Enlist soybean (containing DAS 68416-4). All of these crops contain genetic traits that make them tolerant to the herbicide, 2,4-D; unless specifically stated, all mentions of corn and soybean in this assessment will refer to the 2,4-D herbicide-tolerant varieties that are being assessed. Two of the proposed registrations contain only 2,4-D choline salt as the active ingredient whereas the other two labels are for a 2,4-D-choline salt/glyphosate mixture. The latter would allow applications to herbicide-tolerant corn and soybeans with resistance to both 2,4-D choline salt and glyphosate.

2,4-D choline salt has already been registered for use on conventional corn and soybean, but an ecological risk assessment was not performed on these crops. The proposed application rates and seasonal/annual maximums are similar to those that have been previously assessed for other crops; however, the timing of the applications is different because of the herbicide tolerant trait in corn and soybeans. The trait allows for applications to herbicide-tolerant corn and soybeans that are later in the growing season (later growth stages) than conventional varieties of these crops. Ground boom application is the only recommended method for Enlist corn, field corn containing DAS 68416-4 trait, and herbicide-tolerant soybean.

1.1 Nature of the Chemical Stressor

2,4-D choline salt is a quaternary ammonium salt that rapidly dissociates into a 2,4-D anion and a choline cation. 2,4-D is a plant growth regulator (synthetic auxin herbicide) in the phenoxy or phenoxyacetic acid family that is used as a preplant, pre-emergence, and post-emergence herbicide for the selective control of broadleaf weeds.

Based on the registrant-submitted studies, the following conclusions were drawn regarding the environmental fate and ecological effects of 2,4-D choline salt:

Fate

- The environmental fate strategy for 2,4-D is based on bridging the degradation of 2,4-D esters and 2,4-D salts to 2,4-D acid.

- 2,4-D is an anionic (X-COO- H+) acid under most environmental conditions; it is expected to be mobile to moderately mobile. The vapor pressure (1.4×10^{-7} mm Hg) and Henry's Law Constant (8.56×10^{-6} atm-m^3/mol) indicate that 2,4-D acid has a low volatility.

- The degradation of 2,4-D appears to be dependent on oxidative microbially-mediated mineralization in the terrestrial environment and photodegradation in water.

- Preliminary results from a field volatility study performed with 2,4-D choline salt, 2,4-D ethylhexyl ester (EHE), and 2,4-D dimethylamine salt (DMA salt) suggest that the estimated volatility flux rate of 2,4-D choline salt is lower than the amine and EHE formulations.

- Three major degradates were identified in the submitted environmental fate studies for 2,4-D: 1,2,4-benezenetriol (maximum formed = 37%); 2,4-D-dichlorophenol(2,4-DCP) (maximum formed = 32.6%); and chlorohydroquinone (CHQ) (maximum formed = 16%).

- 2,4-D is unlikely to bioaccumulate in fish given the low value of the log *n*-octanol/water partition coefficient (log K_{ow} = 0.18 at neutral pH).

Ecological

- Ecotoxicity studies for algae, freshwater fish, and honeybee support bridging 2,4-D choline salt data to 2,4-D acid data.

- On an acute basis, 2,4-D acid is practically non-toxic to freshwater fish, estuarine/marine fish, and amphibians; and slightly toxic to freshwater and estuarine/marine invertebrates.

- NOAECs are available for freshwater fish (based on length), estuarine/marine fish (based on survival), and freshwater invertebrates (based on survival and reproduction).

- 2,4-D acid is more toxic to vascular aquatic plants than non-vascular aquatic plants.

- 2,4-D acid is more toxic to dicots than monocots. Seedling emergence toxicity is based on shoot length whereas vegetative vigor toxicity is based on weight.

- 2,4-D acid is slightly (based on dietary study) to moderately toxic (based on oral dose) to birds on an acute basis. There were no observed chronic effects in the reproductive study.

- On an acute basis, 2,4-D acid is slightly toxic to mammals. Chronic effects include: decreased female body weight gain, male renal tubule alteration, increased gestation length, and decreased pup body weight.

- 2,4-D acid is practically non-toxic to adult honeybees.

1.2 Potential Risk to Non-Target Organisms

Ecological risks associated with the new uses of 2,4-D choline salt are summarized below:

- Proposed 2,4-D choline salt uses are not expected to directly adversely affect freshwater or estuarine/marine fish, and freshwater or estuarine/marine invertebrates.
- Proposed 2,4-D choline salt uses are not expected to directly adversely affect aquatic vascular and non-vascular plants.
- Birds may be directly affected by the proposed uses of 2,4-D choline salt on an acute basis. Chronic effects are not expected.
- Mammals may be directly affected by the proposed uses of 2,4-D choline salt on an acute and chronic basis.
- Terrestrial plants (monocots and dicots) may be directly affected by the proposed uses of 2,4-D choline salt.
- The acute contact toxicity test on honeybees demonstrated that 2,4-D choline salt is practically non-toxic; however, the lack of direct effects on terrestrial invertebrates does not preclude concerns for indirect effects.

1.3 Listed Species Assessment

The screening-level analysis for 2,4-D choline salt indicated that there was insufficient information to determine if there were direct effects to mammals (acute and chronic); birds, reptiles, and land-phase amphibians (acute); and terrestrial plants. Indirect effects are determined by assessing the potential for reduction of biologically mediated resources, or habitat modification of listed taxa; however, there was insufficient information to determine if there were indirect effects to any taxa (Table 2).

Table 2. Listed Species Risks Associated with the Proposed New Uses for 2,4-D Choline Salt

Listed Taxa	Direct Effects	Indirect Effects[1]
Terrestrial and semi-aquatic plants: Monocots Dicots	 Insufficient information Insufficient information	 Insufficient information Insufficient information
Birds	Insufficient information – Acute No – Chronic	Insufficient information

Listed Taxa	Direct Effects	Indirect Effects[1]
Terrestrial-phase amphibians[2]	Insufficient information – Acute No – Chronic	Insufficient information
Reptiles[2]	Insufficient information – Acute No – Chronic	Insufficient information
Mammals	Insufficient information – Acute Insufficient information – Chronic	Insufficient information
Aquatic plants: Vascular Non-vascular	 No No	 Insufficient information Insufficient information
Freshwater fish	No – Acute No – Chronic	Insufficient information
Aquatic-phase amphibians[3]	No – Acute No – Chronic	Insufficient information
Freshwater invertebrates	No – Acute No – Chronic	Insufficient information
Mollusks	No – Acute No – Chronic	Insufficient information
Marine/estuarine fish	No – Acute No – Chronic	Insufficient information
Marine/estuarine invertebrates	No – Acute No – Chronic	Insufficient information
Terrestrial invertebrates	No	Insufficient information

[1]Indirect effects to a listed species occur when its resource base is reduced or habitat is modified; indirect effects are possible for all taxa based on potential effects to terrestrial plants and obligate relationships with birds and/or mammals.
[2]Birds are surrogates for reptiles and terrestrial-phase amphibians.
[3]Freshwater fish are surrogates for aquatic-phase amphibians.

1.4 Data Gaps and Uncertainties

Avian Acute Oral Toxicity Test for Passerines (850.2100): The CFR requires data for one passerine species when a chemical is intended for outdoor use. The current method of calculating a weight-adjusted LD_{50} using bobwhite quail or mallard duck data may over- or under-estimate risks to passerines because these birds may metabolize the chemical differently. This study has already been requested through Problem Formulation. A protocol for the study of passerine species should be submitted to EPA for approval prior to study initiation.

Estuarine/Marine Invertebrate Chronic Toxicity Test (850.1350): No acceptable data are available for the chronic toxicity of 2,4-D choline salt to marine/estuarine invertebrates. Currently, the toxicological effects for estuarine/marine invertebrates on a chronic basis remain uncertain for 2,4-D choline salt, although this assessment estimated a chronic value based on an acute-to-chronic ratio using freshwater invertebrate data. Additionally, chronic risk quotients for freshwater invertebrates did not come close to exceeding the level of concern; thus increasing EFED's confidence that the available aquatic invertebrate information is sufficient to evaluate risk.

Terrestrial Plant Seedling Emergence and Vegetative Vigor Tests (850.4100, 850.4150): Typical end-use data are required for terrestrial plants. In the case of the new 2,4-D choline salt registrations, no information is available for the two 2,4-D choline salt formulations, nor the Enlist™ formulation, which is a mixture with glyphosate. For the 2,4-D choline salt-glyphosate formulation, it is anticipated that there could be additional toxicological effects (synergistic or additive) because of the presence of two herbicides. In lieu of these data, toxicity information from other 2,4-D formulations were used as surrogates on an acid-adjusted basis.

Terrestrial Plant Vegetative Vigor Test with Vapor Phase Exposure (non-guideline): 2,4-D is known to volatilize from the field and drift off site under certain environmental conditions. EFED evaluated a vapor-phase study on grapes, cotton, soybean, and tomato; however, the methodology did not include a control, did not measure growth/weight parameters, and was not well-aligned with the 850.4150 protocol. A vapor-phase study with vegetative vigor endpoints is being recommended to further characterize the risk to plants from this exposure route. Grape and cotton should be tested as these were the two most sensitive species in the vapor-phase study that was submitted.

Additionally, the following uncertainties were identified for this risk assessment:

- For terrestrial organisms, only dietary exposure to 2,4-D choline salt was assessed.

- For freshwater fish, birds, and terrestrial insects, definitive acute toxicity data were not available. Acute data were presented as greater than values, making it possible to conservatively compare the toxicity value directly to the EECs to estimate potential risk.

- For terrestrial plants, vegetative vigor toxicity values for monocots were non-definitive. The EC_{25} (a greater than value) was compared directly to the EECs to assess the likelihood of risk. The monocot vegetative vigor NOAEC was a less than value; however, given that seedling emergence data were more sensitive for dicots than the vegetative vigor data, the same pattern was assumed to hold true for monocots. Consequently, the monocot seedling emergence NOAEC was assumed to be the most sensitive monocot NOAEC and used to calculate risk quotients. If this assumption is false, the risk to listed monocots may have been under-estimated.

- In the absence of chronic data for marine/estuarine invertebrates, an acute-to-chronic ratio was calculated to estimate the NOAEC for Eastern oyster.

- This risk assessment only considered the most sensitive of the species evaluated in the registrant-submitted studies. The position of the tested species relative to the distribution of all species' sensitivities to 2,4-D choline salt is unknown. Extrapolating the risk conclusions from the most sensitive tested species to non-tested species may either underestimate or overestimate the potential risks to those species.

- 2,4-D is currently undergoing a Tier I Endocrine Disruptor Screening as required by FFDCA section 408(p). The results of the screening analysis are not yet available.

2. Problem Formulation

The problem formulation provides the foundation for the ecological risk assessment being conducted for the proposed new uses of the herbicide 2,4-D choline salt. As such, it articulates the purpose and objectives of the risk assessment, evaluates the nature of the problem, and provides a plan for analyzing the data and characterizing the risk.

2.1 Nature of Regulatory Action

Under the authority of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Dow Agrosciences LLC is seeking registration for the new uses of 2,4-D choline salt as a foliar spray for the control of broadleaf weeds in herbicide-tolerant soybeans containing DAS-68416-4, and for the control of annual and perennial weeds in herbicide-tolerant Enlist™ corn and herbicide-tolerant field corn (Table 6). See Appendix A for a list of current uses and application information for 2,4-D choline salt.

2.2 Stressor Source and Distribution

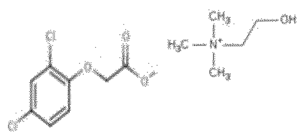
2.2.1 Nature of the Chemical Stressor

2,4-D is a plant growth regulator (synthetic auxin herbicide) in the phenoxy or phenoxyacetic acid family. It is used as a preplant, pre-emergence, and post-emergence herbicide for the selective control of broadleaf weeds. 2,4-D causes disruption of multiple growth processes in susceptible plants by affecting proteins in the plasma membrane, interfering with RNA production, and changing the properties and integrity of the plasma membrane. Disruption of reproductive processes may occur resulting in sterile or multiple florets and nonviable seed production. Symptoms may appear on young growth almost immediately after application, but death may not occur for several weeks.

2.2.2. Environmental Fate Bridging Strategy

The salt and ester forms of 2,4-D are derivatives of 2,4-D acid. The environmental fate strategy for 2,4-D is based on bridging the data on the degradation of 2,4-D esters and 2,4-D salts to 2,4-D acid [Registration Standard for 2,4 Dichlorophenoxyacetic acid (2,4-D), 1988, 540/RS-88-115]. The bridging data provide information on the time of dissociation of 2,4-D amine salts and the rate of hydrolysis of 2,4-D esters. The choline salt of 2,4-D is also considered equivalent to 2,4-D acid. The 2,4-D choline salt has been shown to dissociate rapidly (within 6 seconds) in water (MRID 48260701). However, a field terrestrial study conducted with 2,4-D choline is required to confirm the bridging strategy. Table 3 provides selected physico-chemical properties of 2,4-D choline salt. A detailed environmental fate data bridging strategy can be found in the 2005 Registration Eligibility Document (RED) for 2,4-D (USEPA 2005).

Table 3. Selected Physical and Chemical Properties of 2,4-D Choline Salt

Parameter	Value	Source
Chemical structure		MRID 48260701
Molecular formula and weight (g/mol)	$C_{13}H_{19}Cl_2NO_4$ 324.2	MRID 48260701
Water solubility (mg/L)	Not applicable for end use product	MRID 48208302
Density (g/cm^3)	1.21	MRID 48208302
LogK_{OW}	Not applicable for end use product	MRID 48208302
Vapor pressure (mm Hg@~25ºC)		

2.2.3. Environmental Fate and Transport

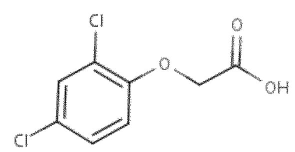
The physicochemical properties in Table 4 suggest that 2,4-D acid is soluble in water (569 mg/L). The vapor pressure (1.4×10^{-7} mm Hg) and Henry's Law Constant (8.56×10^{-6} atm-m^3/mol) indicate that 2,4-D acid has low volatility. The Agency received a field volatility study (MRID 48862902) performed with 2,4-D choline salt, 2,4-D ethylhexyl ester (EHE), and 2,4-D dimethylamine salt (DMA salt). This study is in review at this time; however, preliminary results suggest that the volatility rate of 2,4-D from the choline salt is lower than the DMA and EHE formulations (Figure 1). Additional data and figures are provided in Appendix H. 2,4-D acid is unlikely to bioaccumulate in fish given the low value of the log *n*-octanol/water partition coefficient (log K_{ow} 0.18 at neutral pH).

Table 4 also provides environmental fate properties of 2,4-D acid, along with the major and minor degradates detected in the submitted environmental fate and transport studies. 2,4-D acid is stable abiotic hydrolysis in buffered aqueous solutions at pH 4, 5, 7, and 9. The degradation of 2,4-D acid appears to be dependent on oxidative microbially-mediated mineralization in the terrestrial environment and photodegradation in water. Results from laboratory studies indicate rapid to moderately rapid degradation under aerobic soil conditions with half-lives ranging from 1.4 days to 12.4 days and a median half-life of 2.9 days. Only minor degradates, 2,4-dichlorophenol (2,4-DCP) and 2,4-dichloroanisol (2,4-DCA), were identified in soils. The photodegradation half-life of 2,4-D acid was 12.9 days in a pH 5.0 buffer solution and a major degradate, 1,2,4-benezenetriol (37% of applied) was identified. 2,4-D acid was stable to photodegradation in soil.

2,4-D acid was not stable in aerobic aquatic environments ($t_{1/2}$=15.0 days) but was moderately persistent to persistent ($t_{1/2}$=28.5 to 333 days) in anaerobic aquatic laboratory studies. The major degradates were chlorohydroquinone (CHQ) (maximum of 16.0 % of applied) in aerobic aquatic conditions and 2,4-DCP (maximum of 32.6 % of applied) under anaerobic aquatic environment.

The registrant conducted a total of 30 terrestrial field dissipation studies in CA, CO, NC, ND, NE, OH, and TX on bare ground plots as well as plots cropped with corn, pasture, turf, and wheat. The 2,4-D acid half-lives ranged from 1.1 to 42.5 days with a median half-life of 6.1 days. These half-lives reflect dissipation from the surface soil layer (0 to 6 inches). The data indicate a rapid to moderately rapid dissipation rate for 2,4-D acid. The results of this study are also consistent with half-lives from laboratory studies and confirm the conceptual model for 2,4-D dissipation. The half-lives of 2,4-D degradation products (2,4-DCP and 2,4-DCA) were not estimated because of their sporadic occurrence patterns in surface soils. To address the behavior of 2,4-D in aquatic water systems, a series of aquatic field dissipation studies were conducted. Three studies were conducted using 2,4-D DMA while a fourth study was conducted using 2,4-D BEE. In addition, two field dissipation studies using 2,4-D DMA were also submitted to address forest field dissipation.

Table 4. Physical Chemical and Environmental Fate Properties of 2,4-D Acid

Parameter	Value	Source
Selected Physical/Chemical Parameters		
Chemical Structure		TOXNET
IUAPC Name	(2,4-dichlorophenoxy)acetic acid	U.S. EPA, 2005b
CAS Name	(2,4-dichlorophenoxy)acetic acid	U.S. EPA, 2005b
CAS No.	94-75-7	U.S. EPA, 2005b
Molecular Weight (molecular formula)	221.04 g/mol ($C_8H_6Cl_2O_3$)	U.S. EPA, 2005b
Smiles Code	O=C(O)COc(c(cc(c1)Cl)Cl)c1	EPISUITE4.1
Vapor pressure (25°C)	1.4 x 10^{-7} mm Hg	U.S. EPA, 2005b

Parameter	Value	Source
Aqueous solubility (20°C)	569 mg/L	U.S. EPA, 2005b
Dissociation constants (pKa) in water (25°C)	2.60	MRID 471122-02
Henry's Law Constant (25°C)	8.56×10^{-6} atm-m^3/mol	Rice et al, 1997
Log octanol-to-water partition coefficient (log K_{OW})	2.14 @ pH 5.0 0.18 @ pH 7.0 0.10 @ pH 9.0	U.S. EPA, 2005b
Persistence		
Hydrolysis half-life	Stable	MRID 41007301
Aqueous photolysis half-life	12.98 days Degradates[1] 1,2,4-benzenetriol (37% of applied)	MRID 41125306
Soil photolysis half-life	Stable CO_2 (5% of applied)	MRID 41125305
Aerobic soil metabolism half-life (days)	Catlin Silty clay loam – 1.7 day Commerce Loam –4.62 days Catlin Silty clay loam – 1.4 days Fargo Clay – 12.4 days Keith Clay loam – 4.4 days Walla Walla silt loam – 2.0 days Cecil Sandy loam -2.9 days Degradates 2,4-DCP (3.5%) 2,4-DCA (2.8%)	MRID 43167501, MRID 00116625
Anaerobic aquatic metabolism half-life (total system)	333 days 28.5 days 41.0 days **Degradates** 2,4 DCP (Maximum 32.6% of applied) 4-chlorophenoxy acetic acid(4 - CPA) <2.0% of applied), 4-chlorophenol (4 - CPP) <2.0% of applied), 2,4- DCA (<2% of applied)	MRID 43356001 MRID 42979201 MRID 41557901

Parameter	Value	Source
Aerobic aquatic metabolism half-life (total system)	15 days Inconclusive[2] **<u>Degradates</u>** Chlorohydroquinone (CHQ) (maximum 16% of Applied) 2,4-DCP (4.9 of applied)	MRIDs 42045301 44188601
Mobility		
Adsorption/desorption $K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g) $K_{foc\text{-}ads}$ / (mL/g)	Adsorption Freundlich adsorption $K_{f\text{-}ads}$ values Sand 0.36 Sandy loam 0.17 Loam 0.28 Silty clay loam 0.52 Clay 1.27 Desorption Freundlich adsorption $K_{f\text{-}des}$ values Sand 1.16 Sandy loam 0.87 Loam 1.58 Silty clay loam 1.99 Clay 1.64 Adsorption Freundlich adsorption K_{foc} values Sand 76 Sandy loam 70 Loam 117 Silty clay loam 59 Clay 58.1	MRID 44117901 MRID 42045302 MRID 44117901 MRID 42045302 MRID 44117901 MRID 42045302
Leaching	Thin Layer Chromatography (TLC) Retention Value (R_f, unitless) (Un-aged sample) Sand 1.0 Sandy loam 0.77 Silt loam 0.60 Loam 0.41 Column Study (Aged sample) Immobile	MRID 00057313 MRID 00080124

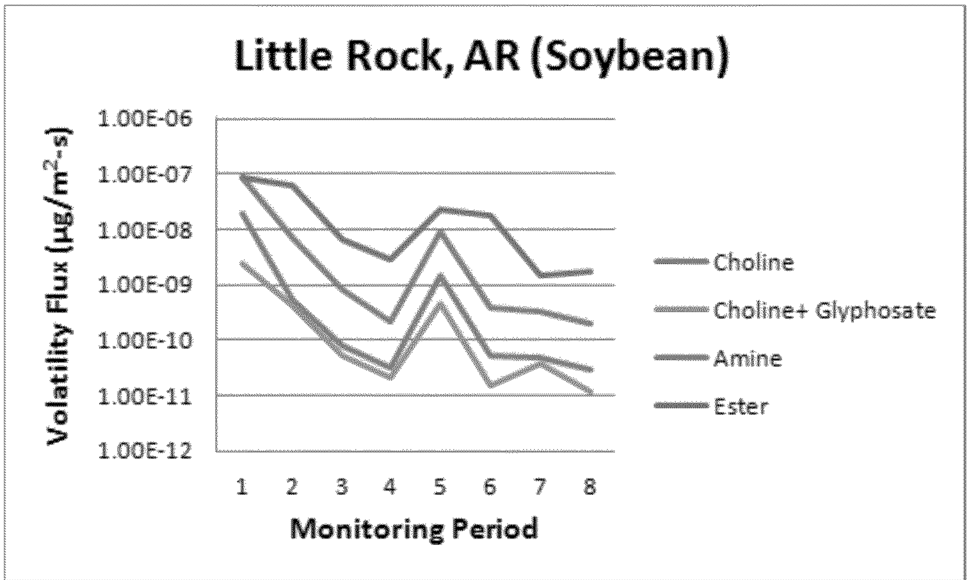
Parameter	Value	Source
Field Dissipation		
Terrestrial field dissipation half-life	The first order half-lives ranged from 1.1 to 42.5 days with a median half-life of 6.1 days	MRID 43914701 MRID 43762401 MRID 43762402 MRID 43514601 MRID 43533401 MRID 43864001 MRID 43592801 MRID 43762403 MRID 43762404 MRID 43640601 MRID 43831702 MRID 43872703 MRID 43849102 MRID 43831701 MRID 43705202
Aquatic field dissipation half-life	Estimated dissipation half-lives of 20.7 and 2.7 days from the North Carolina pond after the first and second applications, 14 days and 6.1 days in water from a North Dakota pond after the first and second applications, and 1.0 day in water from the Louisiana rice paddy after a single application	MRID 43908302 MRID 43491601
Forest Field Dissipation half-life	The estimated half lives for 2,4-D were 59 days in exposed soil, 68 days in protected soil, 42 days on foliage, and 72 days on leaf litter.	MRID 43954702
Field Volatility[3] Maximum Flux Rate (g/m^2-s)	5.50E-09 (Farmland, IN) 1.53E-08 (Fowler, IN) 1.88E-08 (Little Rock, AR) 1.48E-09 (Little Rock, AR)[4] 1.48E-09 (Ty Ty, GA) 2.44E-09 (Ty Ty, GA)[4]	MRID 48862902[5]

[1] Structures of major and minor degradates of 2,4-D are provided in Appendix B
[2] Half-life cannot be calculated because study duration was insufficient
[3] Agency estimated flux rate based on 1.0 lb a.e./A of 2,4-D choline salt
[4] Flux study performed with 2,4-D choline plus glyphosate
[5] Study in review

2.2.4 Degradates

There were three major degradates identified in the submitted environmental fate studies for 2,4-D; 1,2,4-benzenetriol (37% formed), 2,4-dichlorophenol (2,4-DCP) (32.6% formed), and chlorohydroquinone (CHQ) (16% formed). Minor degradates included 4-chlorophenol, 4-CPA and 2,4-DCA (Table 4). The major degradate, 1,2,4-benzenetriol, is a photodegradate that was observed under abiotic conditions and is less likely to occur under natural conditions where microbe-mediated degradation occurs. The 1,2,4-benzenetriol degradate was eliminated from concern because it is formed only via aqueous photolysis. It may be less likely to occur in many environments because degradation of 2,4-D appears to be dependent primarily on oxidative microbial-mediated mineralization. The exposure of CHQ in the environment is likely to be low since it formed in aerobic aquatic environments to a significant extent only on day 27, and, from that point, dissipation was rapid (half-life of 5 days). Although 2,4-DCP is a minor degradate in the terrestrial environment, it is a major degradate (<32%) under anaerobic aquatic conditions. There are some toxicity data for 2-DCP available in the ECOTOX database[1] and the European Footprint database[2] that suggest it is more toxic than 2,4-D for selected aquatic organisms. Therefore, 2,4-D as well as its degradate, 2,4-DCP, will be considered as independent stressors of concern in ecological risk assessment.

Figure 1. Volatility Flux Profile of 2,4-D Formulations



2.2.5 2,4-D Choline Salt Use Characterization

2,4-D choline salt is a non-selective herbicide for the control of broadleaf weeds. The proposed new uses for 2,4-D choline salt include soybeans containing DAS-68416-4, Enlist™ corn, and field corn containing DAS-40278-9. The current action refers to GF-2654 TS (soybean), GF-2654 TC (field corn), GF-2726 (Enlist™ corn), and GF-2727 (Enlist™ corn). GF-2726 and GF-2727 are products that contain both 2,4-D choline salt and glyphosate. Table 6 shows the application rates for each use. All products are applied as a ground foliar spray. The herbicide-tolerant trait allows for a later application in both soybean (R2 stage) and corn (V8 stage).

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[1] http://cfpub.epa.gov/ecotox/
[2] http://sitem.herts.ac.uk/aeru/footprint/en/index.htm

2.3 Receptors

2.3.1 Aquatic and Terrestrial Receptors and Effects

The receptor is a biological entity that is exposed to a stressor (USEPA 1998). Consistent with the process described in the Overview Document, this risk assessment uses a surrogate species approach in its evaluation of 2,4-D choline salt (USEPA 2004). Toxicological data generated from surrogate test species, which are intended to be representative of broad taxonomic groups, are used to extrapolate the potential effects on a variety of species (receptors) included under these taxonomic groupings.

Acute and chronic toxicity data from studies submitted by the pesticide registrant along with available open literature studies are used to evaluate potential direct effects of pesticides to the aquatic and terrestrial receptors. Open literature studies are identified through EPA's ECOTOX database (http://cfpub.epa.gov/ecotox/), which employs a literature search engine for locating chemical toxicity data for aquatic and terrestrial flora and fauna. The evaluation of both sources of data provides insight into the direct and indirect effects of pesticides on biotic communities from loss of species that are sensitive to the chemical and changes in structural and functional characteristics of the affected communities.

A search of the ECOTOX database on October 24, 2012 yielded no studies for 2,4-D choline salt. Therefore, only studies submitted by the registrant were evaluated to determine the effects of 2,4-D choline salt on non-target organisms.

2.3.2 Ecosystems Potentially at Risk

The ecosystems at risk from exposure to a stressor are often extensive in scope; it may not be possible to identify specific ecosystems at the screening level. In general terms, terrestrial ecosystems potentially at risk could include the treated field and areas immediately adjacent to the treated field that may receive drift or runoff. Areas adjacent to the treated field could include other cultivated fields, fencerows and hedgerows, meadows, fallow fields or grasslands, woodlands, riparian habitats, and other uncultivated areas.

Aquatic ecosystems potentially at risk from a stressor include water bodies adjacent to or downstream from the treated field; impounded bodies such as ponds, lakes, and reservoirs; and flowing waterways such as streams or rivers. For uses in coastal areas, aquatic habitat also includes marine ecosystems and estuaries.

2.4 Assessment Endpoints

Assessment endpoints represent the actual environmental value that is to be protected, defined by an ecological entity (species, community, or other entity), and its attribute or characteristics (USEPA 1998, 2005a). For 2,4-D choline salt, the ecological entities include the following: birds, amphibians, reptiles, mammals, insects, freshwater fish and invertebrates, estuarine/marine fish and invertebrates, and aquatic plants and algae. The attributes for each of these entities include survival, growth, and reproduction.

2.5 Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a feasible route of exposure.

A conceptual model is intended to provide a written description and visual representation of the predicted relationships between the stressor, potential routes of exposure, and the predicted effects for the assessment endpoint. A conceptual model consists of two major components: the risk hypothesis and the conceptual diagram (USEPA 1998, 2005a).

2.5.1 Risk Hypothesis

Based on the environmental fate characteristics and mode of action, it is presumed in this screening-level assessment that 2,4-D choline salt, when used in accordance with the label, has the potential to adversely affect survival, growth, and/or reproduction of both terrestrial and aquatic organisms.

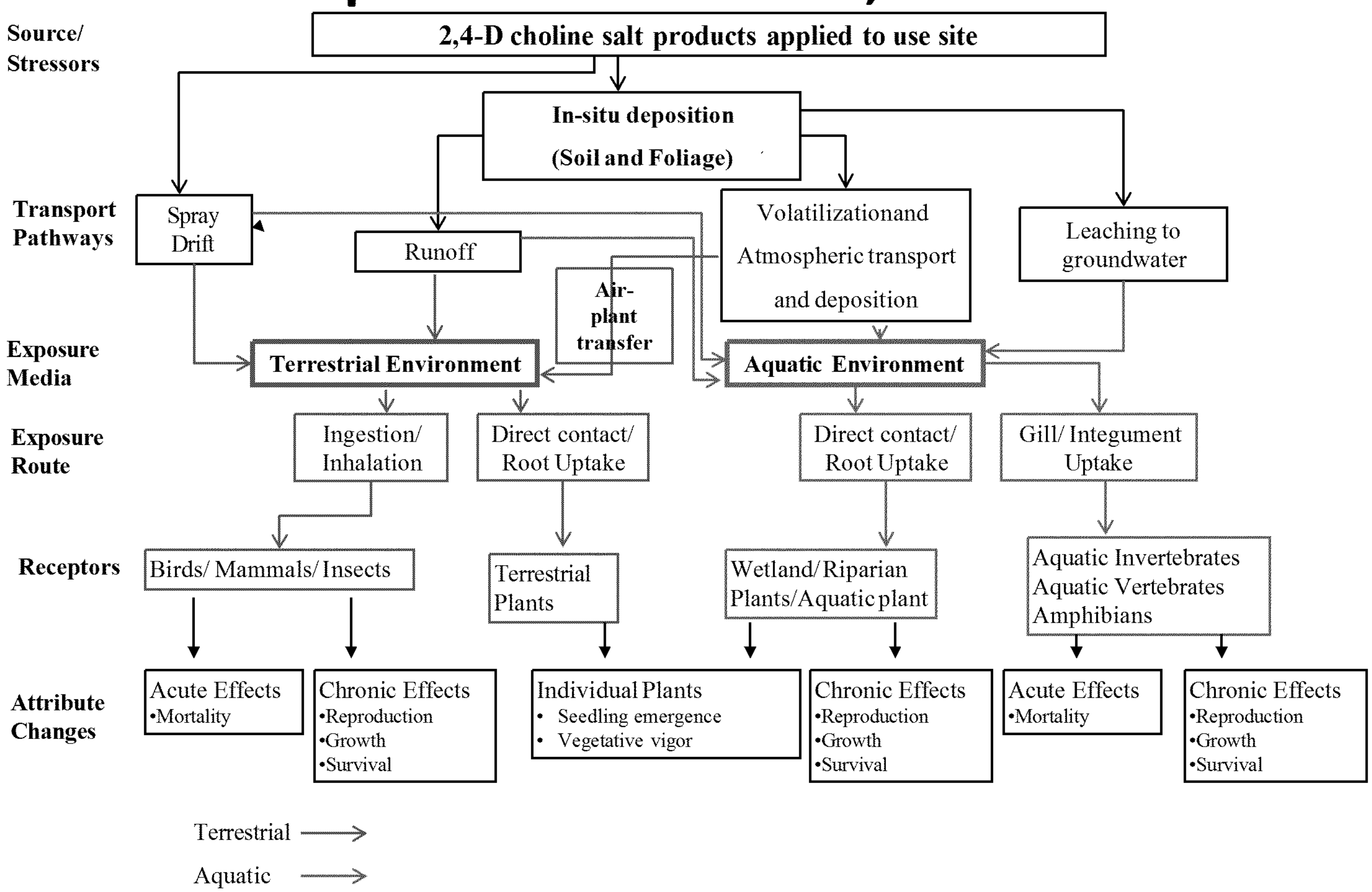
Birds, mammals, amphibians, reptiles, and non-target insects may be exposed to 2,4-D choline salt through direct ingestion of the pesticide on the dietary items, incidental ingestion of contaminated soil, dermal contact with treated plant surfaces and soil during activities in the treated areas, direct impingement of sprayed material on the body at the time of application, preening activities, and ingestion of drinking water contaminated by the pesticide. 2,4-D exposures to aquatic species may occur through spray drift, runoff, volatilization, wet/dry deposition, and leaching to ground water. The seedling emergence and vegetative vigor of non-target terrestrial plants and growth and biomass accumulation of aquatic plants adjacent to the site of 2,4-D choline salt application could be affected by runoff, drift, and volatilization from treated fields.

2.5.2 Conceptual Diagrams

The potential exposure pathways and effects of 2,4-D and its degradates, 2,4-dichlorophenol (2,4-DCP), from applications of 2,4-D choline salt on terrestrial and aquatic environments are depicted in Figure 2. Solid arrows represent the most likely routes of exposure and effects while dashed lines represent potential routes of exposure that are considered less likely for 2,4-D choline salt and its degradates.

Figure 2. Conceptual Model for Exposure Routes for 2,4-D and its Degradates

Exposure Routes for 2,4-D



The conceptual model used to depict the potential ecological risk associated with 2,4-D choline salt (and the degradates of concern) assumes that as an herbicide, 2,4-D choline salt can affect terrestrial and aquatic organisms if environmental exposure is expected as a result of the proposed label uses. The use scenarios for 2,4-D choline salt involve ground spray applications of the herbicide to herbicide-tolerant corn and soybean foliage. While 2,4-D choline salt is already registered on conventional varieties of these crops, the herbicide-tolerant varieties allow for the application of 2,4-D choline salt at later dates in the season. Altering the timing of 2,4-D choline salt applications may change the window of exposure for non-target vegetation. A variety of food types (e.g., short grass, long grass, broadleaf plants) will be assessed regardless of the type represented by the target crop, as a variety of food types exist on and off the treated field.

As there are multiple spray applications to foliage, degradation of the chemical on the foliage between applications is considered in the terrestrial assessments. A default foliar dissipation rate of 35 days will be used in the terrestrial risk assessments since no foliar dissipation studies are available; this may be an over-estimate. For aquatic assessments, the microbial degradation on foliage is assumed stable, but wash-off of the foliage will be considered using the default wash-off coefficient assumption of 0.5 cm^{-1}. Spray drift will be considered in the aquatic assessments as a route of loading to the pond, with higher levels of spray drift for aerial applications than ground spray applications.

2,4-D choline salt will dissociate into its salt and 2,4-D acid upon reaching a water body. It is then partitioned between the water column, suspended sediment, and bed sediment at a ratio based on the pesticide's physical/chemical properties. Degradation by abiotic hydrolysis, photolysis, and microbial mediated metabolism is taken into account.

2,4-D choline salt is unlikely to bio-accumulate in fish; the study was waived because of the low Log K_{ow}.

For birds and mammals, only the dietary route of exposure is considered. Solubility information for 2,4-D choline salt was not available, however; because it rapidly dissociates into 2,4-D acid and the choline salt, it is appropriate to use 2,4-D acid's solubility. Screening for risks from drinking water was performed with the Screening Imbibition Program (SIP). The model identified that exposure through drinking water may present acute and chronic concerns for birds and mammals (Appendix C). The Screening Tool for Inhalation Risk (STIR) did not identify concerns for birds or mammals (Appendix C). Other uncertainties in this risk assessment include the lack of information on exposure from soil ingestion and dermal routes.

2.6 Analysis Plan

The first-tier screening-level risk assessment is used as the approach to determine risk to non-target organisms from the proposed new uses for 2,4-D choline salt. Measures of exposure and effect are used to evaluate the potential risk for a specific assessment endpoint. A risk quotient is obtained by dividing the measures of exposure for a particular assessment endpoint by the measures of effect for that endpoint. The risk quotient is a deterministic point-estimate-based approach and does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. Risk quotients are compared to specified levels of concern; if the risk quotient exceeds the level of concern, then the potential for risk exists.

Polychloro dibenzo-*p*-dioxin (PCDD) and polychloro dibenzo-*p*-furans (PCDF) may be formed during the manufacture of 2,4-D and can remain in the products as impurities. According to 2,4-D registrants, since the 1990's, the manufacturing processes for 2,4-D and its chemical intermediate, dichlorophenol, have been modified to reduce concentrations of PCDD and PCDF in the technical 2,4-D products. The Agency reviewed recently submitted product chemistry data for the end-use (product "GF-2654 TC" to evaluate toxic impurities in 2,4-D choline formulation (U.S. EPA 2012, D405897, Confidential Memo). No PCDD and PCDF were detected above 30% of the limit of quantitation (LOQ) in the registered sources of the active ingredients for 2,4-D choline. Assuming 30% of the LOQ, the toxicity equivalence (TEQ) of PCDD and PCDF was estimated using toxicity equivalence factors derived from the World Health Organization (WHO 2005[3]). The estimated TEQ of the technical product used in 2,4-D choline is approximately 4.8 times lower than the the estimated TEQ calculated for the formulated products of 2,4-dichlorophenoxyaceticacid (2,4-D) and ethylhexyl dichlorophenoxyacetate(2,4-D EHE) in a previous assessment (US EPA 2005, D317729, Confidential Memo). The previous assessment concluded that the environmental loading of PCDD and PCDF from terrestrial and aquatic uses of 2,4-D is not expected to pose a risk for reproductive effects to piscivorous birds and mammals. Therefore, 2,4-D choline salt use in corn and soybean is not expected to pose risk to terrestrial organisms since the TEQ for 2,4-D choline is 4.8 times lower than the formulated products of 2,4-D acid and EHE. No ecological risk assessment is warranted for PCDD and PCDF for 2,4-D choline salt formulationsat this time.

The stressors of ecological concern for terrestrial and aquatic organisms are 2,4-D acid and its degradates. However, as outlined in the degradate section above, all but 2,4-DCP can be eliminated as likely degradates of concern. 2,4-DCP is primarily formed in aquatic environments; it is only a minor degradate in terrestrial environments. Therefore, 2,4-D and degradate 2,4-DCP will be considered as stressors of concern in the aquatic analyses and only 2,4-D will be considered for terrestrial environments.

2.6.1 Measures of Effect and Exposure

The assessment will examine the effects of 2,4-D choline salt (and 2,4-DCP, when relevant) on aquatic and terrestrial environments primarily through the routes of spray drif and runoff. Model details are described later in this section. Several other models are used to characterize effects from vapor exposures, buffer distances, and individual effects probabilities; these are included in the risk description section.

Table 5 lists the measures of environmental exposure and ecological effects used to assess the potential risks of 2,4-D choline salt to non-target organisms. The methods

[3] van den Berg et al., 2006

used to assess risks are consistent with those outlined in the Overview Document (USEPA 2004).

Table 5. Measures of Effect and Exposure for 2,4-D Choline Salt

Assessment Endpoint		Surrogate Species and Measures of Ecological Effect[1]	Measures of Exposure
Birds[2]	Survival	Bobwhite quail oral LD_{50} Bobwhite quail and mallard duck dietary LC_{50}	Maximum residues on food items and soil
	Reproduction and growth	Bobwhite quail reproduction NOAEC	
Mammals	Survival	Laboratory rat oral LD_{50}	
	Reproduction and growth	Laboratory rat two-generation NOAEC and NOAEL	
Freshwater amphibians	Survival	Leopard frog LC_{50}	Peak EEC
Freshwater fish[3]	Survival	Rainbow trout LC_{50}	Peak EEC
	Reproduction and growth	Fathead minnow NOAEC	60-day average EEC
Estuarine/ marine fish	Survival	Tidewater silverside LC_{50}	Peak EEC
	Reproduction and growth	Sheepshead minnow NOAEC	60-day average EEC
Freshwater invertebrates	Survival	Water flea EC_{50}	Peak EEC
	Reproduction and growth	Water flea NOAEC	21-day average EEC
Estuarine/ marine invertebrates	Survival	Eastern oyster LC_{50}	Peak EEC
	Reproduction and growth	Eastern oyster NOAEC[4]	21-day average EEC
Terrestrial plants	Seedling emergence and vegetative vigor	Onion (monocot) Lettuce (dicot) EC_{25} and NOAEC	Maximum residues on foliage and soil

Assessment Endpoint		Surrogate Species and Measures of Ecological Effect[1]	Measures of Exposure
Aquatic plants	Survival and growth	Vascular – Duckweed Non-vascular – Freshwater diatom EC_{50} and NOAEC	Peak EEC
Terrestrial insects	Survival	Honeybee acute LD_{50}	N/A

[1]Risk assessment guidance indicates that the most sensitive species tested within a taxonomic group are to be used for screening level risk assessments.
[2] Birds represent surrogates for reptiles and terrestrial-phase amphibians.
[3] Freshwater fish are surrogates for aquatic-phase amphibians.
[4]Based on acute-to-chronic ratio calculation.

3. Exposure Assessment

3.1 Proposed 2,4-D Choline Salt Application Information

Table 6 shows the maximum application rates for each new use of 2,4-D choline salt, based on the proposed labels. Uses are being expanded to include Enlist corn and soybean containing DAS-68416-4. Additional information regarding the proposed 2,4-D choline salt uses can be found in Section 2.2.2.

Table 6. Proposed 2,4-D Choline Salt Uses

Proposed Label Use	Active Ingredients	Method	Maximum Application Rate (Interval)
GF-2726, GF-2727			
Enlist™ corn	2,4-D choline salt Glyphosate	Ground broadcast spray	<u>Preplant (Burndown)</u> Single application at 1 lb ae/A <u>Preemergence</u> Single application at 1 lb ae/A <u>Postemergence (up to V8 stage - 48 inches)</u> Maximum single application at 1 lb ae/A 2 applications, maximum (12 days) Seasonal maximum of 3 lb ae/A
GF-2654 TC			
Field corn containing DAS-40278-9	2,4-D choline salt	Ground broadcast spray	<u>Preplant</u> Single application at 1 lb ae/A <u>Preemergence</u> Single application at 1 lb ae/A <u>Postemergence (up to V8 stage - 48 inches)</u> Maximum single application at 1 lb ae/A 2 applications, maximum (12 days) Seasonal maximum of 3 lb ae/A
GF-2654 TS			

Proposed Label Use	Active Ingredients	Method	Maximum Application Rate (Interval)
Soybeans containing DAS-68416-4	2,4-D choline salt	Ground broadcast spray	Preplant Single application at 1 lb ae/A Preemergence Single application at 1 lb ae/A Postemergence (up to R2 stage) Maximum single application at 1 lb ae/A 2 applications, maximum (12 days) Seasonal maximum of 3 lb ae/A

3.2 Aquatic Exposure Modeling for 2,4-D Choline Salt

A Tier II screening-level surface water exposure for aquatic risk assessment was conducted for the Section 3 proposed new use registration. Modeled application rates represent the maximum use patterns of the proposed labels for use on herbicide-tolerant corn and soybean. Since the 2,4-D choline salt dissociates rapidly in less than 6 seconds in the environment (MRID 48260701), the aquatic exposure was based on the 2,4-D acid equivalent. Aquatic exposure was also modeled for its major degradate 2,4-DCP, which is more toxic than 2,4-D for selected aquatic organisms (http://cfpub.epa.gov/ecotox/) using the highest exposure scenario for 2,4-D (i.e., MS Corn STD). An additional PRZM/EXAMS model run was performed to estimate the no drift exposure using MS Corn STD scenario for 2,4-D to determine the contribution of spray drift in surface water.

3.2.1 PRZM-EXAMS Model

The Pesticide Root Zone Model, (PRZM, Carsel *et al.*, 1997) and the Exposure Analysis Modeling System (EXAMS, Burns, 1997) were used in tandem to generate aquatic estimated environmental concentrations (EECs). PRZM (3.12.2 dated May 12, 2005) simulates fate and transport on the agricultural field whereas EXAMS (2.98.04.06, dated April 25, 2005) simulates the fate and resulting daily concentrations in the water body. Simulations are carried out with the linkage program shell, PE5V01.pl (dated November 15, 2006), which incorporates the standard agricultural and non-agricultural scenarios developed by EFED. Simulations are run for multiple (usually 30) years, and the EECs represent peak values that are expected once every ten years based on the thirty years of daily values generated during the simulation. Additional information on these models can be found at: http://www.epa.gov/oppefed1/models/water/index.htm

The aquatic exposure is estimated for the maximum application pattern to a 10-ha field bordering a 1-ha pond, 2-m deep (20,000 m^3) with no outlet. Exposure estimates generated using this standard pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that make these water bodies more or less vulnerable than the standard surrogate pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher peak EECs than the standard pond. These water bodies will be either smaller in size or have large drainage areas. Smaller water bodies have limited storage capacity and thus may overflow and carry pesticide in the discharge, whereas the standard pond has no discharge. As watershed size increases beyond 10-ha, it becomes increasingly unlikely that the entire watershed is planted with a non-major single crop that is all treated simultaneously with the pesticide. Headwater streams can also have peak concentrations higher than the standard pond, but they likely persist for only short periods of time and are then carried and dissipated downstream.

Standard PRZM crop scenarios, which consist of location-specific soils, weather, and cropping practices, were used in the simulations to represent proposed labeled uses of 2,4-D choline salt. Standard corn scenarios are available for Illinois, Indiana, Iowa, Kansas, Minnesota, Mississippi, North Carolina, Nebraska, Ohio, and Pennsylvania. A single standard scenario, Mississippi, is available for soybean. The proposed label recommends applying 2,4-D choline salt on corn through the V8 stage (48 inches tall). Applications to soybeans can occur up to the R2 stage (full bloom). 2,4-D choline salt application dates were chosen based on the geographical location of the crop and explored the extended application time period.

2,4-D choline salt labels have a recommendation to use the 2,4-D choline product with an ASABE S-572 droplet size classification of coarse/coarser ($D_{v0.5}$ of ≈ 439 μm) spray quality. Given the limited option for droplet size in the current AgDRIFT ground module, the droplet size of $D_{v0.5}$ of 341 μm option was used as the nearest label recommended coarse/coarser droplet size. Maximum spray drift fractions (0.017) using a droplet size of Dv0.5 of 341 μm as well as no spray drift fraction were evaluated to account for the spray drift contribution in the EECs. Table 9 presents all simulated surface water concentrations of 2,4-D for corn and soybean.

3.2.2 Model Inputs

Input parameters for the PRZM/EXAMS models are listed in Table 7 and Table 8 for 2,4-D and 2,4-DCP respectively. Explanations of the various model input parameters are discussed below. Since 2,4-DCP is a major degradate (32.6%) formed in the aquatic environment but only 3.5% formed in the terrestrial environment, two application rates were used in PRZM/EXAMS modeling to account contribution from terrestrial via runoff/erosion of parent as well as 2,4-DCP and direct deposition from spray drift. 2,4-DCP exposures were modeled for the highest EECs from the parent (MS corn scenario). Using these contributions in tandem requires post-processing of the modeled output to derive a weighted EEC that represents the contribution of runoff/erosion from the terrestrial environment and direct deposition of spray drift to an aquatic environment. A Microsoft Excel spreadsheet was used that allows for the weighting and aggregation of exposure from both scenarios. The daily time series from each model run was copied from the times series file (*_TS.out) generated from the PRZM into the EXCEL spreadsheet . Rolling averages for the relevant durations of exposure (4, 14, 21, and 60 day averages) were estimated using Table 20 of PRZM/EXAMS. Example PRZM/EXAMS model outputs of 2,4-D and post-processed 2,4-DCP EECs were provided in Appendix D.

Table 7. PRZM/EXAMS Input Parameter Values for 2,4-D

Parameter	Value	Source	Comments
Maximum application Rate lb a.e./A (kg a.e./ha)	Corn and Soybean: 1.0 (1.12)	GF-2654 TC 2,4-D (56.3%)	Application rate for GF-2654 for corn and soybean are much higher than GF-2726 (24.4% of 2,4-D,). Therefore no exposure assessment was performed for GF-2726.
Number of Applications	3	GF-2654 TC 2,4-D (56.3%)	1 application for pre-emergence 1 application on emergence date 1 application for post emergence
Minimum Application Intervals (days)	12 (Pre emergence) 12, 21 and 28 (Post emergence)	GF-2654 TC 2,4-D (56.3%)	Minimum application interval before emergence Application intervals for post-emergence
Scenario and Application Date[2]	IA Corn-13-05[1] IL Corn 19-04[2] IN Corn 03-05[1] KS Corn 28-04[2] MN Corn 03-05[1] MS Corn 29-03[2] MS Soybean 04-04[2] NC Corn 03-03[1] NE Corn13-05[2] OH Corn 19-04[2] PA Corn 04-04[1]	Based on PRZM/EXAMS Scenarios	12 days before crop emergence 12-28 days from the date of crop emergence in the scenario
Depth of Incorporation (inches)	0	GF-2654 TC 2,4-D (56.3%)	For foliar application according to Input parameter guidance (USEPA 2009)
Method of Application	Ground spray	GF-2654 TC 2,4-D (56.3%)	---
Application Efficiency	Ground: 0.99	Input parameter guidance (USEPA, 2009)	Default values for ground spray
Spray Drift Fraction	0.017[3]	Estimated	Based on nearest droplet size specification in the submitted labels
Molecular Mass (g/mol)	221.04	USEPA 2005	Product chemistry data
Vapor Pressure (Torr)	1.4×10^{-7}	USEPA 2005	Product chemistry data
Henry's Law Constant (atm m3/mol)	8.56×10^{-6}	Rice et al., 1997	Measured value

ED_Vaughn3_0000562

Parameter	Value	Source	Comments
Solubility in Water (mg/L)	569	USEPA 2005	---
Hydrolysis $t_{1/2}$ at pH 7.0 (days)	0	MRID 41007301	Stable to hydrolysis @ pH 7.0
Aquatic Photolysis $t_{1/2}$ (days)	12.98	MRID 41125306	---
Aerobic Soil Metabolism $t_{1/2}$ (d)	6.92	MRID 43167501 MRID 00116625	90th percentile upper confidence bound on the mean half-life of 2,4-D
Aerobic Aquatic Metabolism $t_{1/2}$ (d)	15 x 3[4]	MRID 420445301	Input parameter guidance (USEPA 2009)
Anaerobic Aquatic Metabolism $t_{1/2}$ (d)	321	MRID 43356001 MRID 42979201 MRID 41557901	90th percentile upper confidence bound on the mean half-life of 2,4-D
Soil Partitioning Coefficient (K_{oc}; ml/g_{oc})	76.02	MRID 44117901 MRID 42045302	Represent average K_{foc} from 5 soils

[1] = PRZM/EXAMS simulations were performed with a single post-emergence crop scenario (12 days after crop emergence)

[2] = PRZM/EXAMS simulations were performed with varied post-emergence crop scenarios (12, 21 and 28 days after crop emergence)

[3] = Spray drift fraction was estimated using AgDRIFT 2.1.1 model –Tier I Ground scenario (High boom, $D_{V0.5}$ 341 µm and 90th percentile data)

[4]= Due to reported half-life for a single aerobic aquatic metabolism study, the input half-life was multiplied by 3 according to guidance for selecting input parameters in modeling for environmental fate and transport of pesticides. Version 2.1 October 22, 2009.

Table 8. PRZM/EXAMS Input Parameter Values for 2,4-DCP

Parameter	Value	Source	Comments
Scenario and Application Date	MS Corn[1]	Based on PRZM/EXAMS Scenario.	12 days before crop emergence. 12days from the date of crop emergence in the scenario
Spray Drift Fraction	1.0	Assumed	To evaluate 2,4-DCP contribution from 2,4-D spray drift
2,4-DCP mass/acre from runoff contribution of parent (lb a.e./A)	0.024	Estimated[2]	To evaluate 2,4-DCP contribution from 2,4-D runoff (10%) based on PRZM manual[3]
Molecular Mass (g/mol)	162.9	USEPA 2005	Product chemistry data

Parameter	Value	Source	Comments
Maximum application Rate lb a.e./A (*kg a.e./ha*)	Corn 0.026 *(0.029)*[4] 0.028 *(0.031)*[5]	Estimated	See calculations in footnotes 3and 4
Number of Applications	3	GF-2654 TC 2,4-D (56.3%)	1 application for pre-emergence 1 application on emergence date 1 application for post emergence
Method of Application	Ground	Assumed	2,4-DCP from post-application parent degradation in terrestrial environment
	Direct Application	Assumed	2,4-DCP contributions from spray drift and 10% of parent from runoff were simulated as a direct application via spray drift into surface water body
Depth of Incorporation (inches)	0	Assumed	For ground application according to Input parameter guidance (USEPA 2009)
Application Efficiency	1.0	Assumed	To evaluate 2,4-DCP contribution from runoff and erosion
	0	Assumed	2,4-DCP ontributions from spray drift and 10% of parent from runoff were simulated via spray drift as a direct application into surface water body
Solubility in Water (mg/L)	4500	TOXNET[6]	Open literature value
Hydrolysis $t_{1/2}$ at pH 7.0 (days)	0	Assumed	No Data
Aquatic Photolysis $t_{1/2}$ (days)	0	Assumed	No Data
Aerobic Soil Metabolism $t_{1/2}$ (d)	75 x 3[7]	EPISUITE[8]	Single value multiplied by 3 according to the Input parameter guidance (USEPA 2009)
Aerobic Aquatic Metabolism $t_{1/2}$ (d)	35.5 x 3[7]	EPISUITE[8]	Single value multiplied by 3 according to the Input parameter guidance (USEPA 2009)
Anaerobic Aquatic Metabolism $t_{1/2}$ (d)	337.5 x 3[7]	EPISUITE[8]	Single value multiplied by 3 according to the Input parameter guidance (USEPA 2009)
Soil Partitioning Coefficient (K_{oc}; ml/g_{oc})	609	EPISUITE[8]	---

Parameter	Value	Source	Comments

[1] PRZM/EXAMS simulation was performed only for MS Corn based on highest EECs observed in 2,4-D exposure
[2] 2,4-D application rate (1.0 lb a.e/A) x [(0.1, runoff contribution of 2,4-D) x (0.326, the maximum conversion rate from the anaerobic aquatic degradation of 2,4-D to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]
[3] http://www.epa.gov/ceampubl/gwater/przm3/przm3123.html
[4] 2,4-D application rate (1.0 lb a.e/A) x [(0.035, the maximum conversion rate for the terrestrial degradation of 2,4-D in the terrestrial environment to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]
[5] 2,4-D application rate (1.0 lb a.e/A) x [(0.017, spray drift contribution of 2,4-D) x (0.326, the maximum conversion rate from the anaerobic aquatic degradation of 2,4-D to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP) + 0.024 lb of runoff contribution]
[6] http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~nU3WAu:1
[7] Due to reported half-life for a single value, the input half-life was multiplied by 3 according to guidance for selecting input parameters in modeling for environmental fate and transport of pesticides. Version 2.1 October 22, 2009
[8] http://www.epa.gov/opptintr/exposure/pubs/episuite.htm

3.2.3 Model Outputs: Aquatic Exposure Estimates

The Mississippi scenario that modeled three applications of 2,4-D choline salt at 1 lb ae/A produced the highest EECs for herbicide-tolerant corn. This same scenario was also modeled without spray drift. In general, results suggest that the EECs for the droplet size of $D_{v0.5}$ of 341 µm are slightly higher (≤ 4%) as compared to the no spray drift fraction (Table 9), which indicates that most of the aquatic exposure is driven by runoff. EECs for the 2,4-DCP degradate were also modeled for Mississippi and were much lower than those for 2,4-D acid (e.g. 6.4 versus 58 µg ae/L for peak EEC; Table 9).

Table 9. Range of Estimated Environmental Concentrations (EECs) of 2,4-D and 2,4-DCP for Surface Water

Drinking Water Source (model)	Use Scenario (modeled rate)	Peak EEC (µg ae/L)	21-Day EEC (µg ae/L)	60-Day EEC (µg ae/L)
Surface Water (PRZM/EXAMS)	**Aquatic Exposure for 2,4-D (Parent)**			
	Corn:			
	IA Corn STD	26.5-21.9	23.8-20.2	19.1-16.7
	IL Corn STD	30.1-24.4	26.6-21.9	22.7-20.0
	IN Corn STD	26.5-24.5	25.3-22.1	20.9-18.9
	KS Corn STD	28.3-23.5	20.9-18.7	13.7-12.5
	MN Corn STD	16.0-14.1	15.1-12.8	13.6-11.7
	MS Corn STD	58.0-57.8	41.6-41.0	29.2-26.4
	NC Corn STD	28.0-21.0	26.5-19.7	23.2-17.5
	NE Corn STD	40.8-36.6	36.4-33.1	28.9-27.9
	OH Corn STD	26.8-16.7	19.3-11.7	11.4-8.8
	PA Corn STD	11.8-10.9	9.6-8.9	6.6-6.6
	(3app. X 1.0 lbs a.e./acre)			

Drinking Water Source (model)	Use Scenario (modeled rate)	Peak EEC (µg ae/L)	21-Day EEC (µg ae/L)	60-Day EEC (µg ae/L)
	Soybean: MS Soybean STD (3app. X 1.0 lbs a.e./acre)	42.8-42.8	32.5-32.5	21.4-21.3
	Corn: MS Corn STD[1] (2app. @ 1.0 lbs and 2 App @0.50 lb a.e./acre)	57.8	41.3	27.3
	Corn: MS Corn STD[2] (3app. X 1.0 lbs a.e./acre)	56.5	40.1	25.3
	Aquatic Exposure for 2,4-DCP (Degradate)			
	Corn: MS Corn STD[3] (3app. x 0.026 lbs a.e./acre)[4] and 3app. x 0.028 lbs a.e./acre)[5]	4.66[6]	3.84[6]	3.62

[1]Post Emergence 2 applications at 0.50 lb a.e./A
[2] PRZM/EXAMS simulated EECs without spray drift fraction to evaluate spray drift contribution
[3] PRZM/EXAMS simulation was performed only for MS Corn based on highest EECs observed in 2,4-D exposure
[4] = 2,4-D application rate (1.0 lb a.e/A) x [(0.035, the maximum conversion rate for the terrestrial degradation of 2,4-D in the terrestrial environment to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]
[5]= Sum of 0.024 lb from runoff contribution and 0.004 lb from spray drift]
[6]= Reported values are based on combining exposures from terrestrial runoff/erosion and spray drift contribution using post processing

3.3 Monitoring Data

Monitoring data considered in the previous assessment (USEPA 2004) were the United States Geological Survey's (USGS) National Water Quality Assessment Program (NAWQA) groundwater and surface water database, USGS/EPA reservoir monitoring database, National Drinking Water Contaminant Occurrence Database (NCOD), and US EPA's Storage and Retrieval environmental data system (STORET). Review of these databases was conducted to provide peak and median concentrations. Additionally, the quality of data was evaluated for targeting pesticide use areas, detection limits, and analytical recoveries. The monitoring data indicate that 2,4-D is detected in groundwater and surface water. The highest time-weighted annual mean (TWAM) concentration was 1.45 µg/L from the NAWQA database containing non-targeted data reflecting pesticide concentrations in flowing water as opposed to more stationary bodies of water such as ponds, lakes, and reservoirs. Also, 2,4-D is detected in treated (finished) drinking water.

Maximum concentrations of 2,4-D in surface source water and ambient groundwater are 58 µg/L and 14.8 ug/L, respectively.

Monitoring data from the USGS NAWQA program were accessed on September 21, 2012 to evaluate the current trend of 2,4-D concentrations in surface water and groundwater. All data of filtered surface water and groundwater were downloaded since the drinking water memorandum was issued in 2004. For surface water, a total of 931 water samples were analyzed for 2,4-D. 2,4-D was detected in 47.0% (i.e. 434 samples from a total national dataset of 931 samples). The maximum concentrations of 2,4-D ranged from 0.008 µg/l to 8.700 µg/L. Even though the maximum concentration of 8.7 µg/L is lower than the previously reported value of 15 µg/L, 2,4-D was detected at a higher percentage in surface water sampled after 2003 as compared to the 23.5% (i.e. 1030 samples from a total national dataset of 4377) reported in the previous drinking water memorandum (USEPA 2004). For groundwater, a total of 1184 water samples were analyzed for 2,4-D. 2,4-D was detected in 1.0% of the samples (i.e. 12 samples from a total national dataset of 1184 samples). The maximum concentrations of 2,4-D ranged from 0.008 µg/L to 1.4 µg/L. Percent of detection and the reported concentration are lower than in the previously reported drinking water memorandum (USEPA 2004). Several mitigation measures may have contributed to the lower concentrations of 2,4-D in NAWQA surface water and groundwater monitoring in the years since the RED was issued (2005). The following mitigation measures were placed in the RED to reduce 2,4-D loading in the environment (USEPA 2005):

- The application rate was reduced from 2.0 to 1.5 lb ae/A per year for turf uses.

- Master label rates were lower than the existing labels rates for various uses. All registrants must conform use rates to those set forth in the 2,4-D master label and reflected in the 2,4-D RED label table.

- Measures to control spray drift described in the "Spray Drift Management" section in the RED to reduce the risk of 2,4-D to non-target plants.

3.4 Terrestrial Exposure Estimates for 2,4-D Choline Salt

The Terrestrial Exposure (T-REX) model (Version 1.5.1), an EFED computer model that uses a first-order dissipation relationship to account for residue dissipation between applications, was used to estimate exposure concentrations of 2,4-D to terrestrial wildlife. The T-REX simulation model incorporates the Kenaga nomogram (Fletcher et al. 1994; Hoerger and Kenaga 1972; Pfleeger et al. 1996) (relationship between the amount of pesticide applied and the amount of pesticide residue present on a given food item). The model also calculates the peak concentration of pesticide residues on each food item on a daily interval for one year using a first order decay function based on the concentrations present from both the initial and additional applications. In addition to exposure concentrations (dose and diet-based), the T-REX model calculates risk quotients based on food items for mammals and birds, including herbivores, insectivores, and granivores. For dose-based exposures, three weight classes of mammals (15, 35, and 1000 g) and birds (20, 100, and 1000 g) are considered.

A default foliar dissipation half-life of 35 days was used in this assessment. Example input parameters, such as application rate, interval, and number of applications, used in the T-REX model are presented with corresponding EECs in Tables 10 and 11 (also Appendix E).

3.4.1 Exposure Estimates for Birds and Mammals

The estimated exposure concentrations of 2,4-D choline salt for birds and mammals are presented in Tables 10 and 11, respectively. These estimates are based on the upper-bound Kenaga dose and the assumption that the species in question eat one type of food item and forage only in the treated and/or overspray areas.

EECs ranged from 26 to 578 mg ae/kg-diet for dietary exposures (birds and mammals). Avian dose-based EECs ranged from 2.34 to 659 mg ae/kg-bw while mammalian dose-based EECs ranged from 1.23 to 552 mg ae/kg-bw (Tables 10 and 11).

Table 10. Avian Exposure Concentration Estimates for Foliar Applications

Feeding Category	Dietary-based EECs (mg/kg-food item)	Dose-based EECs (mg/kg-bw)		
		Small (20 g)	Medium (100 g)	Large (1000 g)
2,4-D choline salt on herbicide-tolerant corn and soybean – 3 applications at 1 lb ae/A (12 day interval)				
Short grass	578.44	658.79	375.67	168.19
Tall grass	265.12	301.94	172.18	77.09
Broadleaf plants	325.37	370.57	211.31	94.61
Fruits/pods	36.15	41.17	23.48	10.51
Arthropods	226.56	258.03	147.14	65.88
Seeds	36.15	9.15	5.22	2.34

Table 11. Mammalian Exposure Concentration Estimates for Foliar Applications

Feeding Category	Dietary-based EECs (mg/kg-food item)	Dose-based EECs (mg/kg-bw)		
		Small (15 g)	Medium (35 g)	Large (1000 g)
2,4-D choline salt on herbicide-tolerant corn and soybean – 3 applications at 1 lb ae/A (12 day interval)				
Short grass	578.44	551.50	381.16	88.37
Tall grass	265.12	252.77	174.70	40.50
Broadleaf plants	325.37	310.22	214.40	49.71
Fruits/pods	36.15	34.47	23.82	5.52
Arthropods	226.56	216.00	149.29	34.61
Seeds	36.15	7.66	5.29	1.23

3.4.2 Exposure Estimates for Plants

TerrPlant 1.2.2 (10/29/09) was used as a Tier 1 model for screening level assessments of pesticides. The model provides estimates of exposure to terrestrial plants from single pesticide applications; however, the model does not consider exposures to plants from multiple pesticide applications. TerrPlant derives pesticide EECs in runoff and in spray drift, and develops risk quotients for non-listed and listed species of monocots and dicots inhabiting dry and semi-aquatic areas (Appendix F).

The estimated exposure concentrations of 2,4-D choline salt for terrestrial plants are presented below (Table 12). The most protective application scenario for each use was selected, based on information from the label. EECs ranged from 0.01 (spray drift) to 0.51 (total for semi-aquatic areas).

Table 12. Terrestrial Plant Exposure Concentration Estimates

Description	Equation	EEC (lb ae/A)
2,4-D Choline Salt and Enlist™ on Corn and Soybeans – single ground application at 1 lb ae/A		
Runoff to dry areas	(A/I)*R	0.05
Runoff to semi-aquatic areas	(A/I)*R*10	0.5
Spray drift	A*D	0.01
Total for dry areas	((A/I)*R)+(A*D)	0.06
Total for semi-aquatic areas	((A/I)*R*10)+(A*D)	0.51

Atmospheric Concentration Analysis

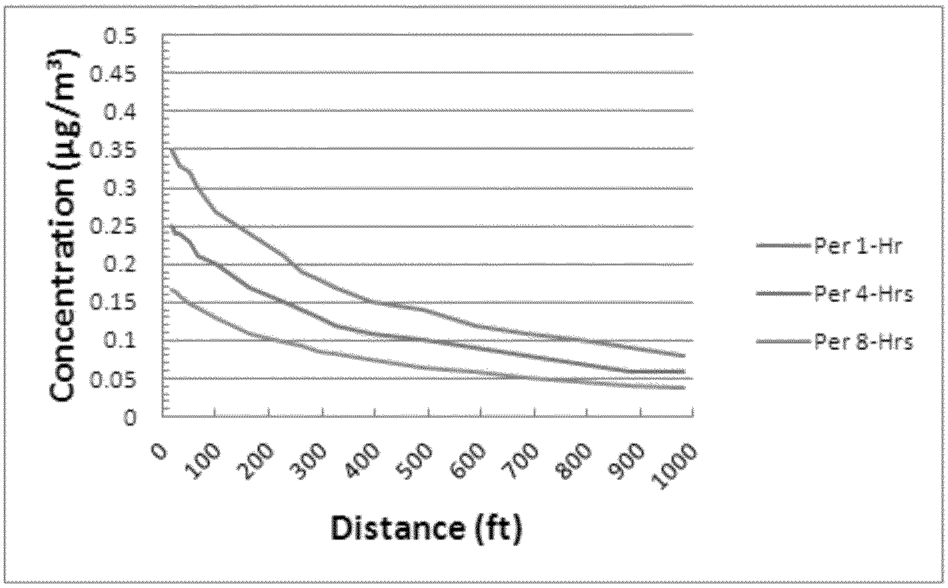
Henry's Law constant of 8.56×10^{-6} atm-m^3/mol indicates that 2,4-D is expected to volatilize from moist soil and water surfaces. The Probablistic Exposure and Risk Model for Fumigants (PERFUM, v. 2.5.1, 7/2/2008) is used in estimating the vapor phase (secondary drift) of 2,4-D in the atmosphere. The PERFUM model is a processor of the ISCST3 model (Reiss and Griffin 2008[4]), which has been developed from EPA's Office of Air Quality Planning and Standards[5]. PERFUM can calculate upper-bound EECs in air near the edge of a field or at a downwind distance of a treated field. PERFUM incorporates actual weather data and flux distribution estimates, and then accounts for changes and altering conditions. Analyses based on a variety of model outputs can be used to compare the potential risks at a range of distances. The PERFUM model and users manual are public and can be downloaded at http://www.epa.gov/opp00001/science/models_pg.htm

The Agency estimated the volatility flux from a submitted field volatility study performed with 2,4-D choline as well as 2,4-D dimethylamine salt (DMA) and 2,4-D ethylhexyl ester (EHE) at four different sites (MRID 48862902). This study is in review

[4] http://www.exponent.com/
[5] The ISCST3 model documentation can be accessed online at: http://www.epa.gov/scram001/dispersion_alt.htm

at this time and preliminary flux profiles are provided in Appendix H. The Agency-estimated highest volatility flux of 1.88 x 10^{-8} g/m^{2-}s from Little Rock, AR was used in the PERFUM modeling. Atmospheric concentrations at the 90th percentile of 2,4-D for corn are depicted at various distances in Figure 3. An example of the input for the PERFUM model is provided in Appendix I.

Figure 3. Estimated 90th Percentile of 2,4-D Concentrations in the Atmosphere



Since the PERFUM model is limited to vapor drift estimation, the AERSCREEN model is used to calculate wet and dry deposition in the environment. AERSCREEN is a screening model, based on the USEPA AERMOD model, designed to produce estimates of "worst-case" 1-hour concentrations for a single source without the need for hourly meteorological data (USEPA 2011). Details of the AERSCREEN model can be obtained from the cited URL[6] below. The highest volatility flux of 1.88 x 10^{-8} g/m^{2-}s from Little Rock, AR was also used in the AERSCREEN modeling. Table 13 provides maximum wet and dry depositions of 2,4-D. The estimated wet and dry depositions were negligible ($\leq$9.60 x 10^{-4} lb a.e/A). Examples of input and output of the AERSCREEN model are provided in Appendix I.

Table 13. Daily AERSCREEN 2,4-D Maximum Total 24-Hour Deposition Results

Time Period (Hours)	Total Field Emissions (lb a.i./A)	Total Field Emissions (% of applied)	Total Dry Deposition (lb a.i./A)	Total Wet Deposition (lb a.i./A)	Total Deposition (lb a.i./A)	Total Deposition (% of applied)	Total Deposition (% of emitted)
Choline Formulation, Corn and Soybeans (EPA Field Emissions)[1]							
0 - 5	1.20 x 10^{-2}	1.204%	1.05 x 10^{-3}	5.00 x 10^{-5}	1.10 x 10^{-3}	-	-
5 – 10	8.43 x 10^{-5}	0.008%	5.00 x 10^{-5}	0	5.00 x 10^{-5}	-	-

[6] http://www.epa.gov/ttn/scram/models/screen/aerscreen_userguide.pdf

Time Period (Hours)	Total Field Emissions (lb a.i./A)	Total Field Emissions (% of applied)	Total Dry Deposition (lb a.i./A)	Total Wet Deposition (lb a.i./A)	Total Deposition (lb a.i./A)	Total Deposition (% of applied)	Total Deposition (% of emitted)
10 - 16	1.59 x 10^{-5}	0.002%	0	0	0	-	-
16 - 23	7.30 x 10^{-6}	0.001%	0	0	0	-	-
23 - 24	4.90 x 10^{-5}	0.005%	2.00 x 10^{-5}	0	2.00 x 10^{-5}	-	-
Total	**1.22 x 10^{-2}**	**1.220%**	**9.60 x 10^{-4}**	**5.00 x 10^{-5}**	**1.17 x 10^{-3}**	**0.117%**	**9.48%**
[1] Deposition values for corn and soybeans the same despite 50 cm and 15 cm release heights modeled, respectively							

Atmospheric Monitoring Data

Data collected in the 1960s and 1970s, and summarized in Majewski and Capel (1995), indicate that 2,4-D has been detected in rainwater samples at concentrations between 50 nanograms per liter (ng/L) and 204,000 ng/L, while 2,4-D was detected in air samples at concentrations between 1.15 nanograms per gram (ng/g) and 1410 ng/g. Majewski and Capel noted that the higher concentrations were infrequently detected, and the authors also noted that the high detections were located near areas where pesticides were applied and may have resulted from unusual conditions. More recent data reported by Anderson *et al.* (2002) on water and rainfall samples in a wetland environment in Alberta, Canada indicate that 2,4-D was one of the most frequently detected pesticides in rainfall samples with a frequency of detection of 65%; however, concentrations did not exceed 1 μg/L. In a study conducted in southern Manitoba by Rawn *et al.* (1999), 2,4-D was detected in rainfall at concentrations less than 1 μg/L and was detected in air as both vapor and particle phase at a maximum concentration of 3500 picograms per cubic meter (pg/m^3). Both rainfall and air detections were closely associated with local use; however, the authors noted that the relative contribution of these compartments to surface water was low compared to runoff.

4. Ecological Effects Assessment

Ecotoxicity data are available for 2,4-D choline salt for a limited number of taxa (acute freshwater fish, acute honeybee, acute freshwater invertebrate, and green algae). These studies support the bridging strategy that has been used for other forms of 2,4-D; 2,4-D toxicity is usually reported in "acid equivalents" so that toxicity data can be compared among forms. For this assessment, 2,4-D choline salt specific data, when available, will be discussed as well as the most sensitive 2,4-D acid equivalent data (the 2005 RED can be consulted for a complete listing of 2,4-D data – USEPA 2005b). Only the most sensitive 2,4-D toxicity value from the broader 2,4-D dataset will be used in risk quotient calculations . Given that there is a difference between the toxicity of esters and amines/salts/acid in aquatic systems, only toxicity data from the latter will be considered for aquatic exposures, unless it is unavailable. Ester data will be used in the absence of salt/amine/acid data. For terrestrial scenarios, the most sensitive 2,4-D toxicity value will be used, regardless of the chemical form.

A search of the ECOTOX database on October 24, 2012 did not yield any 2,4-D choline toxicity studies. Therefore, only studies submitted by the registrant were evaluated to determine the effects of 2,4-D choline salt on non-target organisms. The Ecological Incident Information System (EIIS) was also reviewed to provide a refined characterization of the ecological effects for 2,4-D. The ECOTOX database and European Footprint database yielded toxicological information for aquatic organisms indicating that 2,4-DCP, a major degradate of 2,4-D, is more toxic than 2,4-D. References from the Footprint database were not available for review. ECOTOX sources were not formally reviewed; however the implication of 2,4-DCP's higher toxicity is incorporated into the risk characterization section of the document.

4.1 Aquatic Effects Summary

2,4-D choline salt's effects on aquatic fauna were determined by evaluating freshwater and estuarine/marine fish and invertebrates, and freshwater amphibians. Acute and chronic studies were submitted for freshwater fish, freshwater invertebrates, and estuarine/marine fish, whereas only acute studies were submitted for estuarine/marine invertebrates and freshwater amphibians. In general, 2,4-D choline salt is slightly toxic to fish and invertebrates, and practically non-toxic to aquatic-phase amphibians, on an acute basis.

4.1.1 Toxicity Effects on Fish and Amphibians

An acute freshwater fish limit test for 2,4-D choline salt was available. Neither mortalities nor sub-lethal effects were observed. This study yielded the lowest registrant-submitted endpoint to date for 2,4-D moieties and classifies 2,4-D choline salt as "slightly toxic" to freshwater fish. Acute and chronic studies for other fish and amphibians were not available for 2,4-D choline salt; however, data were available for other 2,4-D forms. The lowest chronic endpoint for freshwater fish was in an early life stage study with the fathead minnow. The study found a decrease in length (most sensitive endpoint) as well as mortality at the highest two concentrations (98.1 and 62.9 mg ae/L) and weight loss at 37.6 mg ae/L. An acute estuarine/marine fish study with the tidewater silverside classified 2,4-D as "slightly toxic" to estuarine/marine fish. No mortalities or sub-lethal effects were observed. Chronic estuarine/marine fish endpoints were only available for ester forms of 2,4-D. The lowest endpoint was based on survival of sheepshead minnow in an early life study. Other effects included a reduction of hatchability at the two highest concentrations (287 and 194 μg ae/L), and reduced length and weight (133 μg ae/L). An acute study with the leopard frog suggests that 2,4-D is "practically non-toxic" to freshwater amphibians. No sub-lethal effects were observed. The study was classified as "supplemental" because it was a non-guideline study; however, it is considered scientifically sound and appropriate for use in risk assessments (Table 14).

Table 14. Toxic Effects in Fish and Amphibians

Test	Species	2,4-D Form Tested	Toxicity Value (mg ae/L)	Study Classification	MRID #
Acute Freshwater Fish	Rainbow trout (*Oncorhynchus mykiss*)	2,4-D choline salt	96-h LC_{50} > 48	Acceptable	48892401
Chronic Freshwater Fish (early life cycle)	Fathead minnow (*Pimphales promelas*)	Dimethylamine salt of 2,4-D	NOAEC = 14.2* Based on length	Acceptable	41767701
Acute Estuarine/ Marine Fish	Tidewater silverside (*Menidia beryllina*)	Diethanolamine salt of 2,4-D	96-h LC_{50} > 80.24	Acceptable	42018301
Chronic Estuarine/ Marine Fish	Sheepshead minnow (*Cyprinodon variegatus*)	Butoxyethyl ester of 2,4-D	NOAEC = 0.05554* Based on survival	Acceptable	41345701
Acute Freshwater Amphibians	Leopard frog tadpoles (*Rana pipiens*)	Dimethylamine salt of 2,4-D	96-h LC_{50} = 278*	Supplemental	44517306
*Denotes value used for calculating risk quotients					

4.1.2 Toxicity Effects on Invertebrates

An acute freshwater invertebratelimit test for 2,4-D choline salt was available using the water flea. One mortality was reported; however, it was considered incidental and not related to the treatment. No sub-lethal effects were observed. The most sensitive endpoint for acute exposures to freshwater invertebrates occurred in a water flea study conducted with 2,4-D acid (MRID 41158301). Sub-lethal effects were not reported for this study; the study classifies 2,4-D as "slightly toxic" to freshwater invertebrates on an acute basis. A freshwater invertebrate chronic study with the water flea yielded endpoints based on survival and reproduction (number of neonates produced, number of broods produced per daphnid, and brood size). No other effects were observed. An acute study with the eastern oyster classified2,4-D as "slightly" toxic to estuarine/marine invertebrates. One mortality occurred at the highest treatment level (155 mg ae/L) and reduced feeding was also observed at this concentration. Shell growth reduction was noted in the other concentrations and the EC_{50} was based on this parameter (Table 15).

Estuarine/marine invertebrate chronic toxicity data were not available. A toxicity value can be estimated based on the assumption that the acute-to-chronic ratio (ACR) for freshwater invertebrates applies to estuarine/marine invertebrates also. Thus, the following equation was used to estimate a NOAEC for eastern oyster, the most sensitive estuarine/marine species on an acute basis (Table 15).

$$\frac{EC_{50(oyster)}}{NOAEC_{(oyster)}} = \frac{EC_{50\ (waterflea)}}{NOAEC_{(waterflea)}} = \frac{49.6}{X} = \frac{25}{16.05} = 31.8 = NOAEC_{(oyster)}$$

Table 15. Toxic Effects in Invertebrates

Test	Species	2,4-D Form Tested	Toxicity Value (mg ae/L)	Study Classification	MRID #
Acute Freshwater Invertebrates	Water flea (*Daphnia magna*)	2,4-D choline salt	48-h EC_{50} > 40.7	Acceptable	48892402
Acute Freshwater Invertebrates	Water flea (*Daphnia magna*)	2,4-D acid	48-h LC_{50} = 25*	Acceptable	41158301
Chronic Freshwater Invertebrates	Water flea (*Daphnia magna*)	Diethanolamine salt of 2,4-D	NOAEC = 16.05* Based on survival and reproduction	Acceptable	42018303
Acute Estuarine/ Marine Invertebrates	Eastern oyster (*Crassostrea virginica*)	Isopropylamine salt of 2,4-D	96-h EC_{50} = 49.6*	Acceptable	41429003
Chronic Estuarine/ Marine Invertebrates	Eastern oyster (*Crassostrea virginica*)	ACR	NOAEC = 31.8* Based on ACR	ACR	ACR
*Denotes value used for calculating risk quotients					

4.1.3 Toxicity Effects on Plants

A non-vascular aquatic plant study for 2,4-D choline salt was available using green algae. Yield and growth rates were affected at the 23.3 mg ae/L treatment. The most sensitive endpoint for non-vascular plants was derived from a freshwater diatom study and was based on growth inhibition. An aquatic vascular plant study with duckweed was available. The most sensitive endpoints were a reduction in frond number and plant number. At the two highest treatment levels (2.11 and 1.03 mg ae/L), colony break up and root destruction were observed; there was a statistically significant increase in frond chlorosis as well (Table 16).

Table 16. Toxic Effects in Aquatic Plants

Test	Species	2,4-D Form Tested	Toxicity Value (mg ae/L)	Study Classification	MRID #
Non-Vascular Aquatic Plant	Green algae (*Pseudokirchneriella subcapitata*)	2,4-D choline salt	72-h IC_{50} > 45.85 NOAEC = 23.3	Acceptable	48892405
Non-Vascular Aquatic Plant	Freshwater diatom (*Navicula pelliculosa*)	Dimethylamine salt of 2,4-D	EC_{50} = 3.88*	Acceptable	41505903
Vascular Aquatic Plant	Duckweed (*Lemna gibba*)	Diethanolamine salt of 2,4-D	EC_{50} = 0.2992*	Acceptable	42712204
*Denotes value used in risk quotient calculations					

4.2 Terrestrial Effects Summary

2,4-D choline salt's effects on terrestrial organisms were determined by evaluating toxicity data for birds, mammals, insects, and terrestrial plants. Acute and chronic studies were submitted for birds and mammals; acute contact data were available for honeybees. Vegetative vigor and seedling emergence data were available for plants. In general, 2,4-D choline salt is practically non-toxic to terrestrial insects, slightly toxic to mammals, and moderately toxic to birds, on an acute basis. Terrestrial dicots appear to be more sensitive than monocots.

4.2.1 Toxicity Effects on Birds

2,4,-D choline salt's toxicity to birds was evaluated through acute oral exposure, acute dietary exposure, and chronic dietary exposure. Birds are considered a surrogate for terrestrial-phase amphibians and reptiles, in the absence of taxa-specific data.

The acute oral toxicity study was conducted with the northern bobwhite quail and resulted in a classification of "moderately toxic" to birds on an acute oral basis. Toxic symptoms prior to death were lethargy, reduced reaction to external stimuli, depression, lower limb weakness, wing droop, prostrate posture, loss of righting reflex, and a ruffled appearance. Sub-lethal effects included a drop in body weight at two of the treatment levels (218.7 and 135 mg ae/kg-bw). There was also a decrease in food consumption at the 218.7 mg ae/kg-bw treatment level during the first 3 days after dosing, but this was compensated for by a 2-3 times higher food consumption rate from days 4 through 14 (Table 17).

Two acute dietary studies were available, classifying 2,4-D choline salt as "practically non-toxic" on an acute dietary basis to birds. No mortalities occurred in either study.

The northern bobwhite quail study exhibited a slight decrease in body weight gain at the 3035 and 1706 mg ae/kg-diet treatment levels. The mallard duck study exhibited a decrease in body weight gain and feed consumption, but only at the highest treatment level (3035 mg ae/kg-diet) (Table 17).

The chronic reproduction study was performed with the northern bobwhite quail. Two mortalities occurred, but they were considered incidental and not related to the treatment. No sub-lethal effects were observed.

Table 17. Toxic Effects in Birds

Test	Species	2,4-D Form Tested	Toxicity Value	Study Classification	MRID #
Acute Oral Toxicity	Northern bobwhite quail (*Colinius virginianus*)	Triisopropanol amine salt of 2,4-D	LD_{50} = 218.7 mg ae/kg-bw* NOAEL = 67.5 mg ae/kg-bw	Acceptable	41644401
Acute Dietary Toxicity	Northern bobwhite quail (*Colinius virginianus*)	Triisopropanol amine salt of 2,4-D	LC_{50} > 3035 mg ae/kg-diet NOAEL = 961 mg ae/kg-diet	Acceptable	41644402
Acute Dietary Toxicity	Mallard Duck (*Anas platyrhynchos*)	Triisopropanol amine salt of 2,4-D	LC_{50} > 3035 mg ae/kg-diet NOAEL = 1706 mg ae/kg-diet	Acceptable	41644403
Chronic Reproduction	Northern bobwhite quail (*Colinius virginianus*)	2,4-D acid	LOAEC > 962 mg ae/kg-diet NOAEC = 962 mg ae/kg-diet* No effects	Acceptable	45336401
*Denotes value used for risk quotient calculation					

4.2.2 Toxicity Effects on Mammals

The acute toxicity of 2,4-D choline salt to mammals was assessed using the oral gavage study conducted on laboratory rat. Based on the LD_{50}, 2,4-D choline salt is moderately toxic to mammals on an acute basis. The two-generation chronic study with the laboratory rat indicated several endpoints in parents and offspring growth (see Table 18) to be the most sensitive. Some reproductive effects were also identified (Table 18).

Table 18. Toxic Effects in Mammals from Acute Oral Exposure to 2,4-D Choline Salt

Test	Species	2,4-D Form Tested	Toxicity Value	Study Classification	MRID #
Acute Oral	Rat (*Rattus norvegicus*)	Triisopropanol amine salt of 2,4-D	LD_{50} = 441 mg ae/kg-bw*	Acceptable	41413501
Chronic Two-Generation Reproduction	Rat (*Rattus norvegicus*)	2,4-D acid	Parental NOAEL = 5 mg ae/kg-bw Based on decreased female weight gain (F_1) and male renal tubule alteration (F_0 and F_1) Reproductive NOAEL = 20 mg ae/kg-bw Based on increase in gestation length Offspring NOAEL = 5 mg ae/kg-bw Based on decreased pup body weight	Acceptable	00150557 00163996
*Denotes value used for calculating risk quotients					

4.2.3 Toxicity Effects on Non-Target Insects

There are contact toxicity data for 2,4-D choline salt. The study had several incidental deaths in the control and four of the five treatment groups; none were considered statistically significant. Three bees were observed to be either apathetic (slow response to stimuli) or affected (reduced coordination), but the effects were not dose responsive. The most sensitive 2,4-D toxicity value is derived from a honeybee study with 2-ethylhexyl ester of 2,4-D. It classifies 2,4-D as "practically non-toxic" to honeybees on an acute contact basis. Sub-lethal signs of toxicity included lethargy, immobility, loss of equilibrium and hyper excitability (Table 19).

Table 19. Toxic Effects in Honeybee (*Apis mellifera*)

Test	2,4-D Form Tested	Toxicity Value (µg ae/bee)	Toxicity Classification	Study Classification	MRID #
Contact Toxicity	2,4-D choline salt	LD_{50} > 89.4 NOAEL = 89.4	Practically non-toxic	Acceptable	48892404
Contact Toxicity	2-ethylhexyl ester of 2,4-D	LD_{50} > 66 NOAEL = 33	Practically non-toxic	Acceptable	43982101

4.2.4 Toxicity Effects on Plants

Typical end-use product data are not available for the 2,4-D choline salt. Given that a dual herbicide product is being registered – 2,4-D choline salt/glyphosate– data for this herbicide combination are necessary for a thorough toxicological assessment. The stress of simultaneous exposure to two herbicides may cause additive or synergistic effects in terrestrial plants and lead to increased toxicity. Conversely, the herbicides could interfere with each other and cause a decrease in the toxicity of the product. Finally, the herbicides may operate independently and the observed toxicity may be equivalent to the more toxic of the two chemicals.

For this risk assessment, data from other forms of 2,4-D were used as surrogates for the 2,4-D choline salt and 2,4-D choline salt/glyphosate products. For seedling emergence, onion was the most sensitive monocot and lettuce was the most sensitive dicot. Shoot length was the most sensitive parameter for both species, as well as for four of the other species that were tested (tomato, cucumber, soybean, turnip). Seedling emergence was the most sensitive parameter for one species (cabbage) and other toxicological observations included chlorosis and leaf curl. Onion and lettuce were also the most sensitive species for the vegetative vigor test. The most sensitive parameter for onion was fresh weight. Leaf distortion and necrosis were also observed. The most sensitive parameter for lettuce was dry weight. Chlorosis, necrosis, leaf curl, stem curl, wilt, and adventitious growth were also reported as effects. Overall, the vegetative vigor and seedling emergence studies indicate that 2,4-D choline salt is slightly more toxic to dicots than monocots (Table 20).

Table 20. Toxic Effects in Terrestrial Vascular Plants

Test	Species	2,4-D Form Tested	Toxicity Value (lb ae/A)	Study Classification	MRID #
Seedling Emergence	Monocot = Onion (*Cepa allium)* Dicot = Lettuce (*Lactuca sativa*)	Isopropylamine salt of 2,4-D	<u>Monocot</u> EC_{25} = 0.010* NOAEC = 0.005628* Based on shoot length <u>Dicot</u> EC_{25} = 0.00081* NOAEC = 0.00047*	Acceptable	43982101

Test	Species	2,4-D Form Tested	Toxicity Value (lb ae/A)	Study Classification	MRID #
			Based on shoot length		
Vegetative Vigor	Onion (*Cepa allium*)	2,4-D acid	EC_{25} > 0.0075 NOAEC < 0.0075 Based on fresh weight	Acceptable	42416801
Vegetative Vigor	Lettuce (*Lactuca sativa*)	2-ethylhexyl ester of 2,4-D	EC_{25} = 0.0021* NOAEC = 0.00167* Based on dry weight	Acceptable	47106004
*Denotes value used for calculating risk quotients					

4.3 Incident Database Review

The Environmental Protection Agency maintains an incident database system called the Ecological Incident Information System (EIIS) to track and evaluate accidental kills associated with pesticide use. Based on the information contained in the incident report, the likelihood of a particular pesticide causing the incident is classified as highly probable, probable, possible, or unlikely. If there are incidents, this information will be reviewed and considered in conjunction with the degree to which the levels of concern were exceeded, information on sales, local use practices, and monitored levels in the environment to determine whether the predicted effect based on the labeled use of the product is likely to occur or not.

A search of the EIIS, Avian Incident Monitoring System, and the Incident Database System on October 31, 2012 did not identify any ecological incidents attributed to 2,4-D choline salt. Although incident reporting is required under FIFRA Section 6(a)(2), the absence of additional reports in EIIS does not indicate that the chemical has no effects on wildlife; rather, it is possible that incidents have gone unreported. Registrations for 2,4-D choline salt are relatively recent (first registration occurred March 2011), thus, the time frame for collecting incidents is short. Given that 2,4-D choline salt is similar in its toxicity and mode of action to other 2,4-D forms, the full suite of 2,4-D incidents was considered in this risk assessment. The 2,4-D Problem Formulation contains a comprehensive list of all incidents reported in the EIIS as of August 6, 2012 (USEPA 2012). The database contained approximately 460 plant incidents, 22 fish incidents, 2 non-specified aquatic incidents, 4 mammal incidents, 4 bird incidents, and 1 honeybee incident.

Given that 2,4-D is an herbicide, it is not surprising that the vast number of reported incidents are related to plants. Many of these were lawn/turf grass incidents where browning or mortality occurred as a result of the application (some applications were considered “misuse,” but many were registered uses). In agricultural settings, direct treatment and spray drift were commonly cited as the cause of damage. Overall, the diversity and number of reported plant incidents supports the premise that 2,4-D has the potential to affect non-target plants.

Many of the other incidents (fish, aquatics, bird, mammals, honeybee) involved other chemicals in addition to 2,4-D. The presence of more than one pesticide, especially if 2,4-D is not explicitly tested for and detected, increases the uncertainty of the cause of the incident. Below is a list of the incidents that were most likely caused by 2,4-D (Table 21). These incidents demonstrate that registered uses of 2,4-D may have adverse effects on non-target fish and birds.

Table 21. Selected Ecological Incidents Associated with 2,4-D from the EIIS Database

	Incident Number (Source)	Taxa	Magnitude	Year	State	Use	Legality of Use	Certainty Category	2,4-D Residues	Other Chemicals Involved	Comments
2,4-D	I000636-017	Catfish	Several	1987	MO	Home/ lawn	Registered	High probability	N/R	No	Mortality caused by runoff into a pond
2,4-D	I000799-003	Turkey Cardinal Blackbird Duck Bream Bass	Duck, Bream, Bass – hundreds All others – Unknown	1991	NC	Home/lawn	Not determined	Probable	2,4-D tested for in duck and blackbird tissue; 2,4-D detected in water – 1 ppb	Dicamba Mecoprop Carbaryl Diazinon Pentachlorophenol Oxamyl	Mortality caused by ingestion (birds) and runoff into stream (fish)
2,4-D	B0000-300-37	Drum Bream Croaker	100 fish each	1984	SC	N/R	Not determined	Probable	N/R	No	Mortality caused by ingestion
2,4-D	I000925-001	Unknown fish	23000	1993	WV	Right-of-way, rail	Registered	High probability	Confirmed in water, concentration not reported	Triclopyr	Mortality caused by drift into stream

5. Risk Characterization

Risk characterization is the integration of exposure and effects to determine the ecological risk associated with the proposed new uses for 2,4-D choline salt. The risk characterization provides estimates and descriptions of the risk; articulates risk assessment assumptions, limitations, and uncertainties; synthesizes an overall conclusion; and provides risk managers with information to make regulatory decisions.

5.1 Risk Estimation

The risk quotient method was used to determine if 2,4-D choline salt has the potential to cause adverse effects to non-target organisms. In the risk quotient method, the estimated environmental concentrations (EECs) are divided by acute and chronic toxicity values. The resulting unit-less risk quotients are compared to the Agency's levels of concern to determine the need for regulatory action (Appendix G).

5.1.1 Summary of Aquatic Risk Quotients

5.1.1.1 Risk Quotients for Fish

Risk quotients were calculated for acute effects on freshwater amphibians and chronic effects on freshwater and estuarine/marine fish (Table 22). Acute risk quotients for freshwater amphibians and fish ranged from <0.001 to 0.001 and did not exceed the acute listed or non-listed species LOCs (0.05 and 0.1, respectively). Likewise, the chronic LOC of 1 was not exceeded for freshwater fish (range of < 0.001 to 0.002) or estuarine/marinefish (range of 0.09 to 0.53).

Table 22. Acute Risk Quotients for Freshwater Amphibians and Chronic Risk Quotients for Freshwater Fish and Estuarine/Marine

Drinking Water Source (model)	Use Scenario (modeled rate)	Chronic risk to freshwater fish 60-day EEC/NOAEC (NOAEC = 14200 µg ae/L)	Acute risk to freshwater amphibians Peak EEC/LC_{50} (LC_{50} = 278000 µg ae/L)	Chronic risk to estuarine/ marine fish 60-day EEC/NOAEC (NOAEC = 55.4 µg ae/L)
	Aquatic Exposure for 2,4-D (Parent)			
Surface Water (PRZM/EXAMS)	Corn: IA Corn STD IL Corn STD IN Corn STD KS Corn STD MN Corn STD MS Corn STD NC Corn STD NE Corn STD OH Corn STD PA Corn STD (3app. X 1.0 lbs a.e./acre)	 0.001-0.001 0.001-0.002 0.001-0.002 0.001-0.001 0.001-0.001 0.002-0.002 0.001-0.002 0.002-0.002 0.001-0.001 <0.001-<0.001	 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001 <0.001-<0.001	 0.34-0.30 0.41-0.36 0.38-0.43 0.25-0.23 0.25-0.21 0.53-0.48 0.42-0.32 0.52-0.50 0.21-0.16 0.12-0.12
	Soybean: MS Soybean STD (3app. X 1.0 lbs a.e./acre)	0.002-0.002	<0.001-<0.001	0.39-0.38
	Corn: MS Corn STD[1] (2app. @ 1.0 lbs and 2 App @0.50 lb a.e./acre)	0.002	<0.001	0.49
	Corn: MS Corn STD[2] (3app. X 1.0 lbs a.e./acre)	0.002	<0.001	0.46

[1]Post Emergence 2 applications at 050 lb a.e./A
[2] PRZM/EXAMS simulated EECs without spray drift fraction to evaluate spray drift contribution
[3] PRZM/EXAMS simulation was performed only for MS Corn based on highest EECs observed in 2,4-D exposure
[4] = 2,4-D application rate (1.0 lb a.e/A) x [(0.035, themaximum conversion rate for the terrestrial degradation of 2,4-D in the terrestrial environment to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]
[5]= 2,4-D application rate (1.0 lb a.e/A) x [(0.017, spray drift contribution of 2,4-D) x (0.326, the maximum conversion rate from the anaerobic aquatic degradation of 2,4-D to 2,4-DCP from laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]

5.1.1.2 Risk Quotients for Aquatic Invertebrates

A summary of risk quotients for acute and chronic exposures of 2,4-D choline salt to freshwater and estuarine/marine invertebrates is presented in Table 23, below. Risk quotients ranged from <0.001 to 0.002 (acute) and <0.001 to 0.003 (chronic) for freshwater invertebrates. Risk quotients ranged from <0.001 to 0.001 (acute and chronic) for estuarine/marine invertebrates. None of the LOCs were exceeded for any scenario (acute listed = 0.05; acute non-listed = 0.1; chronic = 1).

Table 23. Acute and Chronic Risk Quotients for Aquatic Invertebrates Exposed to 2,4-D Choline Salt in Surface Water

Drinking Water Source (model)	Use Scenario (modeled rate)	Acute risk to freshwater invertebrates Peak EEC/LC_{50} (LC_{50} = 25000 µg ae/L)	Chronic risk to freshwater invertebrates 21-day EEC/NOAEC (NOAEC = 16050 µg ae/L)	Acute risk to estuarine/ marine invertebrates Peak EEC/EC_{50} (EC_{50} = 49600 µg ae/L)	Chronic risk to estuarine/ marine invertebrates 21-day EEC/NOAEC (NOAEC = 31800 µg ae/L)
Surface Water (PRZM/EXAMS)	**Aquatic Exposure for 2,4-D (Parent)**				
	Corn: IA Corn STD IL Corn STD IN Corn STD KS Corn STD MN Corn STD MS Corn STD NC Corn STD NE Corn STD OH Corn STD PA Corn STD (3app. X 1.0 lbs a.e./acre)	0.001-0.001 0.001-0.001 0.001-0.001 0.001-0.001 0.001-0.001 0.002-0.002 0.001-0.001 0.002-0.001 0.001-0.001 <0.001-<0.001	0.001-0.001 0.002-0.001 0.002-0.001 0.001-0.001 <0.001-<0.001 0.003-0.003 0.002-0.001 0.002-0.002 0.001-0.001 0.001-0.001	0.001-<0.001 0.001-<0.001 0.001-<0.001 0.001-<0.001 <0.001-<0.001 0.001-0.001 0.001-<0.001 0.001-0.001 0.001-<0.001 <0.001-<0.001	0.001-0.001 0.001-0.001 0.001-0.001 0.001-0.001 <0.001-<0.001 0.001-0.001 0.001-0.001 0.001-0.001 0.001-<0.001 <0.001-<0.001
	Soybean: MS Soybean STD (3app. X 1.0 lbs a.e./acre)	0.002-0.002	0.002-0.002	0.001-0.001	0.001-0.001
	Corn: MS Corn STD[1] (2app. @ 1.0 lbs and 2 App @0.50 lb a.e./acre)	0.002	0.003	0.001	0.001
	Corn: MS Corn STD[2] (3app. X 1.0 lbs a.e./acre)	0.002	0.002	0.001	0.001

Drinking Water Source (model)	Use Scenario (modeled rate)	Acute risk to freshwater invertebrates Peak EEC/LC_{50} (LC_{50} = 25000 µg ae/L)	Chronic risk to freshwater invertebrates 21-day EEC/NOAEC (NOAEC = 16050 µg ae/L)	Acute risk to estuarine/ marine invertebrates Peak EEC/EC_{50} (EC_{50} = 49600 µg ae/L)	Chronic risk to estuarine/ marine invertebrates 21-day EEC/NOAEC (NOAEC = 31800 µg ae/L)

[1]Post Emergence 2 applications at 0.50 lb a.e./A
[2] PRZM/EXAMS simulated EECs without spray drift fraction to evaluate spray drift contribution
[3] PRZM/EXAMS simulation was performed only for MS Corn based on highest EECs observed in 2,4-D exposure
[4] = 2,4-D application rate (1.0 lb a.e/A) x [(0.035, the maximum conversion rate for the terrestrial degradation of 2,4-D in the terrestrial environment to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]
[5]= 2,4-D application rate (1.0 lb a.e/A) x [(0.017, spray drift contribution of 2,4-D) x (0.326, the maximum conversion rate from the anaerobic aquatic degradation of 2,4-D to 2,4-DCP from laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]

5.1.1.3 Risk Quotients for Aquatic Plants

A summary of risk quotients for acute and chronic exposures of 2,4-D choline salt to freshwater and estuarine/marine invertebrates is presented in Table 24, below. Risk quotients ranged from 0.002 to 0.015 for non-vascular aquatic plants and 0.021 to 0.194 for vascular aquatic plants. None of the risk quotients exceeded the LOC of 1 for aquatic plants.

Table 24. Risk Quotients for Aquatic Plants Exposed to 2,4-D Choline Salt in Surface Water

Drinking Water Source (model)	Use Scenario (modeled rate)	Risk to non-vascular plants Peak EEC/EC_{50} (EC_{50} = 3880 µg ae/L)	Risk to aquatic vascular plants Peak EEC/EC_{50} (EC_{50} = 299.2 µg ae/L)
	Aquatic Exposure for 2,4-D (Parent)		
Surface Water (PRZM/EXAMS)	Corn: IA Corn STD IL Corn STD IN Corn STD KS Corn STD MN Corn STD MS Corn STD NC Corn STD NE Corn STD OH Corn STD PA Corn STD (3app. X 1.0 lbs a.e./acre)	 0.007-0.006 0.008-0.006 0.007-0.006 0.007-0.006 0.004-0.004 0.015-0.015 0.007-0.005 0.011-0.009 0.007-0.004 0.003-0.003	 0.089-0.073 0.101-0.082 0.089-0.082 0.095-0.079 0.053-0.047 0.194-0.193 0.094-0.070 0.136-0.122 0.090-0.056 0.039-0.036

Drinking Water Source (model)	Use Scenario (modeled rate)	Risk to non-vascular plants Peak EEC/EC_{50} (EC_{50} = 3880 µg ae/L)	Risk to aquatic vascular plants Peak EEC/EC_{50} (EC_{50} = 299.2 µg ae/L)
	Soybean: MS Soybean STD (3app. X 1.0 lbs a.e./acre)	0.011-0.011	0.143-0.143
	Corn: MS Corn STD[1] (2app. @ 1.0 lbs and 2 App @0.50 lb a.e./acre)	0.015	0.193
	Corn: MS Corn STD[2] (3app. X 1.0 lbs a.e./acre)	0.015	0.189

[1]Post Emergence 2 applications at 0.50 lb a.e./A
[2] PRZM/EXAMS simulated EECs without spray drift fraction to evaluate spray drift contribution
[3] PRZM/EXAMS simulation was performed only for MS Corn based on highest EECs observed in 2,4-D exposure
[4] = 2,4-D application rate (1.0 lb a.e/A) x [(0.035, themaximum conversion rate for the terrestrial degradation of 2,4-D in the terrestrial environment to 2,4-DCP in laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]
[5]= 2,4-D application rate (1.0 lb a.e/A) x [(0.017, spray drift contribution of 2,4-D) x (0.326, the maximum conversion rate from the anaerobic aquatic degradation of 2,4-D to 2,4-DCP from laboratory studies) x (0.74, the molecular weight ratio of 2,4-D to 2,4-DCP)]

5.1.2 Summary of Terrestrial Risk Quotients

5.1.2.1 Avian and Mammalian Risk Quotients

Acute toxicity risk quotients were based on the oral toxicity study for the northern bobwhite quail. Risk quotients ranged from 0.01 to 4.18. “Seeds” was the only dietary item that did not yield a risk quotient that exceeded the listed species LOC (0.1). The non-listed species LOC (0.5) was exceeded for small and medium birds consuming short grass, tall grass, broadleaf plants, and arthropods; and for large birds consuming short grass. The listed species LOC was exceeded for all of these scenarios as well as small and medium birds consuming fruits/pods; and large birds consuming tall grass, broadleaf plants, and arthropods. The chronic risk quotients ranged from 0.04 to 0.60 and did not exceed the chronic LOC of 1 (Table 25).

Table 25. Summary of Avian Acute and Chronic Risk Quotients (RQs) for 2,4-D Choline Salt for Foliar Applications

Feeding Category	Chronic (dietary-based) RQs	Acute (dose-based) RQs		
		Small (20 g)	Medium (100 g)	Large (1000 g)
2,4-D choline salt on herbicide-tolerant corn and soybean – 3 applications at 1 lb ae/A (12 day interval)				
Short grass	0.60	**4.18****	**1.87****	**0.59****
Tall grass	0.28	**1.92****	**0.86****	**0.27***
Broadleaf plants	0.34	**2.35****	**1.05****	**0.33***
Fruits/pods	0.04	**0.26***	**0.12***	0.04
Arthropods	0.24	**1.64****	**0.73****	**0.23***
Seeds	0.04	0.06	0.03	0.01
*Exceeds listed species LOC of 0.1 **Exceeds non-listed species LOC of 0.5				

The dose-based acute mammalian risk quotients ranged from <0.01 to 0.57. The listed species LOC (0.1) was exceeded for small, medium, and large mammals consuming short grass, tall grass, broadleaf plants, and arthropods. In addition, small mammals consuming short grass also exceeded the non-listed species LOC (0.5). Chronic dose-based risk quotients ranged from 0.32 to 50.2. The chronic LOC of 1 was exceeded for all size classes of mammals consuming all food items except for seeds. Chronic dietary-based risk quotients ranged from 0.36 to 5.78. The chronic LOC of 1 was exceeded for diets of short grass, tall grass, broadleaf plants, and arthropods (Table 26).

Table 26. Summary of Mammalian Acute and Chronic Risk Quotients (RQs) for 2,4-D Choline Salt Foliar Applications

Risk Quotients Based on Kenaga Upper Bound EEC	Dose-Based RQs						Chronic Dietary-Based RQs
	15 g		35 g		1000 g		
	Acute	Chronic	Acute	Chronic	Acute	Chronic	
2,4-D choline salt on herbicide-tolerant corn and soybean – 3 applications at 1 lb ae/A (12 day interval)							
Short grass	**0.57****	**50.2*****	**0.49***	**42.9*****	**0.26***	**23.0*****	**5.78*****
Tall grass	**0.26***	**23.0*****	**0.22***	**19.7*****	**0.12***	**10.5*****	**2.65*****
Broadleaf plants	**0.32***	**28.2*****	**0.27***	**24.1*****	**0.15***	**12.9*****	**3.25*****
Fruits/pods	0.04	**3.14*****	0.03	**2.68*****	0.02	**1.44*****	0.36
Arthropods	**0.22***	**19.7*****	**0.19***	**16.8*****	**0.10***	**9.00*****	**2.27*****
Seeds	0.01	0.70	0.01	0.60	<0.01	0.32	0.36
*Exceeds the acute listed species LOC of 0.1 **Exceeds the acute non-listed species LOC of 0.5 ***Exceeds chronic LOC of 1.0							

5.1.2.2 Plant Risk Quotients

Risk quotients exceeded the LOC (1) for all exposure scenarios. Risk quotients ranged from 1 to 90.62 for monocots and 12.35 to 1085.11 for dicots. Risk was attributed to both spray drift and runoff from treated fields (Table 27).

Table 27. Summary of Risk Quotients for Terrestrial Plants Exposed to 2,4-D Choline Salt through Runoff and/or Spray Drift

Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
2,4-D Choline Salt and Enlist™ on Corn and Soybeans – single ground application at 1 lb ae/A				
Monocot	non-listed	**6.00***	**51.00***	**1.00***
Monocot	listed	**10.66***	**90.62***	**1.78***
Dicot	non-listed	**74.07***	**629.63***	**12.35***
Dicot	listed	**127.66***	**1085.11***	**21.28***
*Exceeds LOC of 1.				

5.1.2.3 Non-Target Insect Risk Quotients

Currently, EFED does not routinely quantify potential risks of pesticides to terrestrial non-target adult insects. Based on the acute contact data submitted for honeybees, 2,4-D choline salt is practically non-toxic (LD_{50} > 66 µg ae/bee). Bees or other beneficial insects could be exposed to 2,4-D choline salt through residues left on foliage or direct contact during the foliar spray application. Current data indicate that it is unlikely that such exposures would be lethal, although some sub-lethal effects were noted in the study (lethargy, immobility, loss of equilibrium, and hyper excitability). While the honeybee is used as a surrogate for all terrestrial insects, there is uncertainty in this assumption in that some other species of insects may be more sensitive to 2,4-D choline salt.

5.2 Risk Description

The results of this screening-level risk assessment indicate that direct effects are not expected for aquatic organisms; birds, reptiles, and land-phase amphibians (chronic), and terrestrial insects. There is insufficient information to determine how the proposed new uses of 2,4-D choline salt will directly affect mammals (acute and chronic), birds (acute), and terrestrial plants, and indirectly affect all taxonomic groups. The registrant submitted a stewardship plan (MRID 48862903) that is undergoing evaluation by the Biological Economics and Analysis Division. In addition, two risk assessment documents were supplied by the registrant and considered by EFED (MRIDs 48897101, 48897102). The risk assessments focused on listed species in the six "launch" states; however, the methodology employed was not in line with methods used by the Agency (i.e., fitted spray drift curve, no air analysis, species sensitivity distributions). The following sections discuss the results of the risk quotient analysis, implications of incident data, and explore several additional analyses to further characterize the risks and elucidate potential mitigation options.

5.2.1 Probit Slope Response Analysis of LOC Values and Acute RQ Values

As part of the risk estimation, the probability of mortality associated with the listed acute LOC values is estimated along with the probability of acute mortality occurring if exposure at the EEC actually occurs. The probability of mortality calculations are based on the probit slope dose-response relationship. The probability of mortality for an exposed individual is calculated using an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004).

The model provides the option of inserting taxa-specific probit slopes and confidence intervals. If specific information is not available, the model uses a default value of 4.5 for the probit slope and 2 and 9 for the upper and lower 95% confidence interval bounds. For 2,4-D choline salt, taxa-specific data were only available for birds; default values were used for mammals.

Probabilities of mortality were only calculated for scenarios where the risk quotient exceeded the acute listed species LOC. For 2,4-D choline salt, there were two groups that met this criterion – birds and mammals (Table 28).

Table 28. Probability of Mortality for an Individual Bird or Mammal for 2,4-D Choline Salt

	RQ (range)	Slope	95% Confidence Interval	Odds (1 in…)
Birds	4.18 – 0.12	6.4	2.7 and 10.1	1 – 528,000,000
Mammals	0.57 – 0.10	4.5	2 and 9	7.35 – 294,000

5.2.2 AgDrift Analysis for Terrestrial Plants, Birds, and Mammals

Applied 2,4-D choline can drift from the treated area and still be present at concentrations that exceed acute levels of concern for birds, mammals, and terrestrial plants. Buffers may offer a potential mitigation strategy to reduce the concentration of 2,4-D choline salt that reaches non-target organisms. 2,4-D choline labels have a recommendation to use the 2,4-D choline product with an ASABE S-572 droplet size classification of coarse/coarser spray quality. Given the limited option for droplet size in the current AgDRIFT ground module, the droplet size distribution of fine to medium/coarse ($D_{v0.5}$ of 341 µm) option with 90th data percentile and high boom was used to estimate spray drift buffer distances. The results indicate that buffers could be set to mitigate adverse effects from spray drift to non-target monocots, mammals, and birds. Buffers for dicots would need to be greater than 1000 ft to mitigate the risk from spray drift, which is probably not a practical solution (Table 29).

The Agency explored an alternative approach to determine buffer distances using the label-recommended droplet spectrum. The registrant submitted a spray drift field study (MRID 48844001, in review) with various drift reduction nozzles and formulations for spray drift management. A cursory review of the study showed that the combination of an AIXR 11004 nozzle and the GF2726 formulation may be a feasible alternative for off-site drift management. The Agency considered this specific combination of nozzle and formulation to determine the potential for off-target movement of the 2,4-D choline salt. The deposition data show a biphasic distribution (Figure J-1, Appendix J) with a bias toward near field deposition. To determine far-field deposition, the Agency truncated the deposition data from 0 to10 feet and used 90th percentile data from 25 to 400 feet to determine buffer distances (Figure J-2, Appendix J). The deposition curve was developed using Exponential Decay, Double, 4 Parameter equation using SigmaPlot version 10.0. The Exponential Decay, Double, 4 Parameter (EDDP) and various coefficients are listed below:

f= 25(ft) + a*exp(-b*x)+c*exp(-d*x)

Where:

25 ft represents 0 distance for the deposition curve

a = 0.0013, b = 0.0388, c = 0.0006, and d = 0.0012

Table 29 shows that the buffer distances for dicots are shorter (62 to 202 ft) when estimated using the above equation as compared with the AgDRIFT model.

Table 29. Spray Drift Buffer Distances for 2,4-D Choline Salt for Birds, Mammals, and Terrestrial Plants

Use – herbicide-tolerant soybean and corn	Single application rate (lb ae/A)	Fraction of applied	Buffer distance (ground application) (ft)	
			AgDRIFT[1]	EDDP[2]
Listed monocots	1	0.005628	135	NA
Non-listed monocots	1	0.010	66	NA
Listed dicots	1	0.00047	>1000	202
Non-listed dicots	1	0.00081	961	62
Listed mammals	1	0.175	3	NA
Non-listed mammals	1	0.877	3	NA
Listed birds	1	0.024	23	NA
Non-listed birds	1	0.120	7	NA

[1] AgDRIFT ground boom scenario with fine to medium/coarse droplet, high boom (50 inches), and 90th data percentile

[2] Represent deposition data (25 to 400 ft) from AXIR11004 nozzle and GF2726 formulation at boom height of 50 inches with 7mph (MRID 4884001)

NA- Not applicable due to truncated data.

5.2.3 Risk to Aquatic Vertebrates and Invertebrates

The proposed uses of 2,4-D choline salt did not exceed any levels of concern for chronic exposures to freshwater fish and estuarine/marine fish. Likewise, risk quotients for freshwater and estuarine/marine invertebrates did not exceed acute or chronic LOCs. Risk quotients could not be calculated for acute effects to freshwater and estuarine/marine fish because the toxicological values were non-definitive. Thus, the non-definitive values were compared directly with the EECs. The highest peak EEC (MS Corn Scenario = 58 µg ae/L) is less than the freshwater fish LC_{50} (LC_{50} > 48000 µg ae/L) and the estuarine/marine fish LC_{50} (LC_{50} > 80240 µg ae/L). This suggests that the concentration of 2,4-D in aquatic environments as a result of the proposed new uses on corn and soybean is not high enough to result in acute adverse effects to freshwater and estuarine/marine fish.

Data from the European Footprint database and ECOTOX database indicate that 2,4-DCP, a major degradate of 2,4-D, is more toxic to fish and invertebrates than 2,4-D. Footprint database toxicity values could not be evaluated because the Agency did not have access to the actual studies. Likewise, the open literature studies from the ECOTOX database were not reviewed in-depth. However, based on the aquatic EECs for 2,4-DCP that were generated from the new uses on herbicide-tolerant corn and soybean, it is unlikely to pose a problem for freshwater fish and invertebrates. In all cases, the EECs for 2,4-DCP are much lower than the reported toxicity values (Table 30).

Table 30. 2,4-DCP Toxicity Values and Toxicity Thresholds for Freshwater Fish and Invertebrates

	Reported acute value	Acute EECs	Reported chronic value	Chronic EECs
Freshwater fish	1000 μg/L[2]	4.66 μg/L	290 μg/L[2]	3.84 μg/L
Freshwater invertebrates	1400 μg/L[1,2]	4.66 μg/L	210 μg/L[2]	3.62 μg/L
[1]European Footprint Database [2]ECOTOX Database				

Incident data suggest registered uses of 2,4-D result in mortality and toxic effects in freshwater fish. However, the application rate may have been higher than those of the proposed new uses. Given that the risk quotients, which were modeled with the highest application rates for herbicide-tolerant corn and soybean, were far below the LOCs, it is not expected that aquatic organisms will be at direct risk from these proposed new uses.

The proposed 2,4-D choline salt formulations for registration are reported to maintain some properties that may reduce spray drift to non-target areas. While EFED has received some information regarding these properties, the full suite of data necessary to analyze these properties is not available. Given that these data and other potential mitigation options are not finalized, EFED has determined that insufficient information is available to make an effects call for indirect effects to aquatic invertebrates and fish.

5.2.4 Risk to Terrestrial Animals

Mammals

Risk quotients for mammals exceeded the Agency's LOCs for mammals for acute dose-based exposure and chronic dose-based and dietary-based exposure. The listed species LOC was exceeded for small, medium, and large mammals consuming short grass, tall grass, broadleaf plants, and arthropods; small mammals consuming short grass exceeded the non-listed species LOC. The chronic dose-based LOC was exceeded for all size classes of mammals consuming all food items except for seeds. The chronic dietary-based LOC was exceeded for diets of short grass, tall grass, broadleaf plants, and arthropods for mammals. Thus, the risk quotient analysis predicts direct risks are expected for listed mammals.

Likewise, indirect effects are predicted for mammals based on the risk quotients that exceeded the non-listed mammal LOC, terrestrial plants, and birds. Indirect effects may occur when mammals depend on a terrestrial plant, bird, or other mammal that is adversely affected by 2,4-D choline salt. Terrestrial plants provide food and habitat for mammals. Birds and other mammals may be food sources for listed species as well.

For acute exposures, the probit slope response analysis indicated a 1 in 7.35 chance of an individual mammal being affected at the highest RQ and a 1 in 294,000 chance of an individual mammal being affected at the lowest RQ that exceeded the LOC.

2,4-D is currently undergoing a Tier I Endocrine Disruptor Screening as required by FFDCA section 408(p). Effects noted in the two-generation rat reproduction study included decreased female weight gain (F_1) and male renal tubule alteration (F_0 and F_1) in the parental generations. An increase in gestation length was documented as a reproductive effect and pup body weight was decreased compared with the controls.

The proposed 2,4-D choline salt formulations for registration are reported to maintain some properties that may reduce spray drift to non-target areas. While EFED has received some information regarding these properties, the full suite of data necessary to analyze these properties is not available. Given that these data and other potential mitigation options are not finalized, EFED has determined that insufficient information is available to make an effects call for direct and indirect effects to mammals.

Birds, Reptiles, and Terrestrial-Phase Amphibians
Avian risk quotients exceeded the LOC for acute exposures. The non-listed species LOC was exceeded for small and medium birds consuming short grass, tall grass, broadleaf plants, and arthropods; and for large birds consuming short grass. The listed species LOC was exceeded for all of these scenarios as well as small and medium birds consuming fruits/pods; and large birds consuming tall grass, broadleaf plants, and arthropods. Thus, the risk quotient analysis indicates that direct effects are predicted for birds on an acute basis; no chronic risks are expected. Incident data also support this conclusion. Several incidents (~4) involving birds have been reported to the Agency. In particular, one incident involved four species of birds (blackbird, cardinal, duck, and turkey. 2,4-D acid was applied to a lawn and an unknown number of birds were reported to have died via ingestion of the pesticide. 2,4-D was detected in surface water at the site; however it was not specifically detected in any of the bird tissues that were sampled. An additional uncertainty is the application of six other pesticides in a similar time frame (dicamba, mecoprop, carbaryl, diazinon, pentachlorophenol, and oxamyl).

Based on the risk quotient analysis, indirect effects from the proposed 2,4-D choline salt uses are predicted for birds. Several non-listed bird LOCs were exceeded. Birds that depend on terrestrial plants, mammals, or other birds for habitat and food may be affected as the risk quotient analysis predicts risks to these groups.

Effects that may be seen in birds prior to death are lethargy, reduced reaction to external stimuli, depression, lower limb weakness, wing droop, prostrate posture, loss of righting reflex, and a ruffled appearance. Other effects may include a drop in body weight and food consumption; however, in laboratory studies, the birds began to recover several days after the acute exposure had taken place.

The proposed 2,4-D choline salt formulations for registration are reported to maintain some properties that may reduce spray drift to non-target areas. While EFED has received some information regarding these properties, the full suite of data necessary to analyze these properties is not available. Given that these data and other potential mitigation options are not finalized, EFED has determined that insufficient information is available to make an effects call for direct (acute only) and indirect effects to birds, reptiles, and terrestrial-phase amphibians.

Terrestrial insects were not identified to be at risk from the proposed new uses of 2,4-D choline salt, based on honeybee toxicity data.

5.2.5 Risks to Terrestrial Plants

All terrestrial plant risk quotients exceeded the LOC; risk was a result of spray drift and runoff. Thus, the risk quotient analysis indicates that direct effects are predicted from the proposed new uses of 2,4-D choline salt to terrestrial plants. Incident data support this conclusion as the majority of incidents reported to the agency were for plants (~460). 2,4-D choline salt is an herbicide, thus it is not unexpected that even small amounts of spray drift or runoff could cause adverse effects in non-target species. It should be noted that none of these incidents were specifically for 2,4-D choline salt as the initial registration for this chemical is relatively new; all the incidents were all for other older forms of 2,4-D.

A further uncertainty is attached to the 2,4-D choline salt/glyphosate product. The product contains two herbicides with different modes of action; however, no terrestrial plant data for this formulation are available. It is unknown if such a formulation will have additive or synergistic effects (increased toxicity) or interference effects (decreased toxicity) on terrestrial plants. Taking a conservative approach, it is possible that the 2,4-D choline salt/glyphosate formulation will be more toxic to plants than the single active ingredient products.

The risk quotient analysis predicted indirect effects for terrestrial plants. Plants may depend on other plants to modify the environment so that they can grow (e.g., succession in a field). Plants may also rely on birds and mammals for pollinator and seed dispersal services; the risk quotient analysis suggests that birds and mammals may be at direct risk from the proposed 2,4-D choline salt new uses.

Based on the risk quotient analysis, dicots were more sensitive to 2,4-D choline salt than monocots. The spray drift analysis, using the AIXR 11004 nozzle and the GF2726 formulation, indicates that buffers of 62 feet (non-listed) and 202 feet (listed) is sufficient to protect dicots from exposures of 2,4-D choline salt that exceed the Agency's levels of concern.

In addition to death, effects seen in plants may include decreased stem growth, decreased weight, necrosis, leaf and stem curl, wilting, and adventitious root growth.

Potential effects from the volatilization of 2,4-D choline salt after application to fields were also considered. A plant vapor study was submitted to evaluate the effects that 2,4-D vapor from a treated field may have on neighboring non-target species (MRID 48911801). The study did not use controls and presented qualitative observations on the percent of visual plant damage (necrosis, cupping of leaves at margins, epinasty, twising of foliage, swelling or increased growth on the main stem at petiole attachment) for grapes, cotton, tomato, and soybeans. Grape was the most sensitive species followed by cotton, tomato, and then soybean. Plant damage endpoints are not normally used quantitatively in risk assessments and their sensivity, compared with growth/weight endpoints, is unknown.

In addition to the laboratory study, the registrant submitted several field studies that related plant damage in grape, cotton, and soybean to growth or yield endpoints (Table 31). The studies were all considered scientifically sound and appropriate for qualitative incorporation into a risk assessment. All were field studies and there was variation in the methodology and timing of measurements. Crop yields were measured at the end of the growing season or harvest. The height endpoint was measured at 14 and 28 days after treatment, but only the 14 day value is presented here as this corresponds to the vegetative vigor guideline study. In addition to variation in field sites (location, year, month), some fields also received applications of pesticides (not herbicides) to control insects and other pests. These variables introduce some uncertainty into the studies; however, they do simulate real-life field conditions. Consequently, the results of the studies are considered appropriate for risk characterization.

Table 31. Percent of Plant Damage Producing Significant Effects in Growth/Yield for Grape, Cotton, and Soybean

Species	Percent Damage	Endpoint	Citation
Grape	20%	Growth/Yield	Ogg et al. 1991
Cotton	58%	Yield	Marple et al. 2008
Cotton	62-66%	Yield	Everitt and Keeling 2009
Soybean	35%	Yield	Robinson et al. unpublished
Soybean	35%	Yield	Andersen et al. 2004

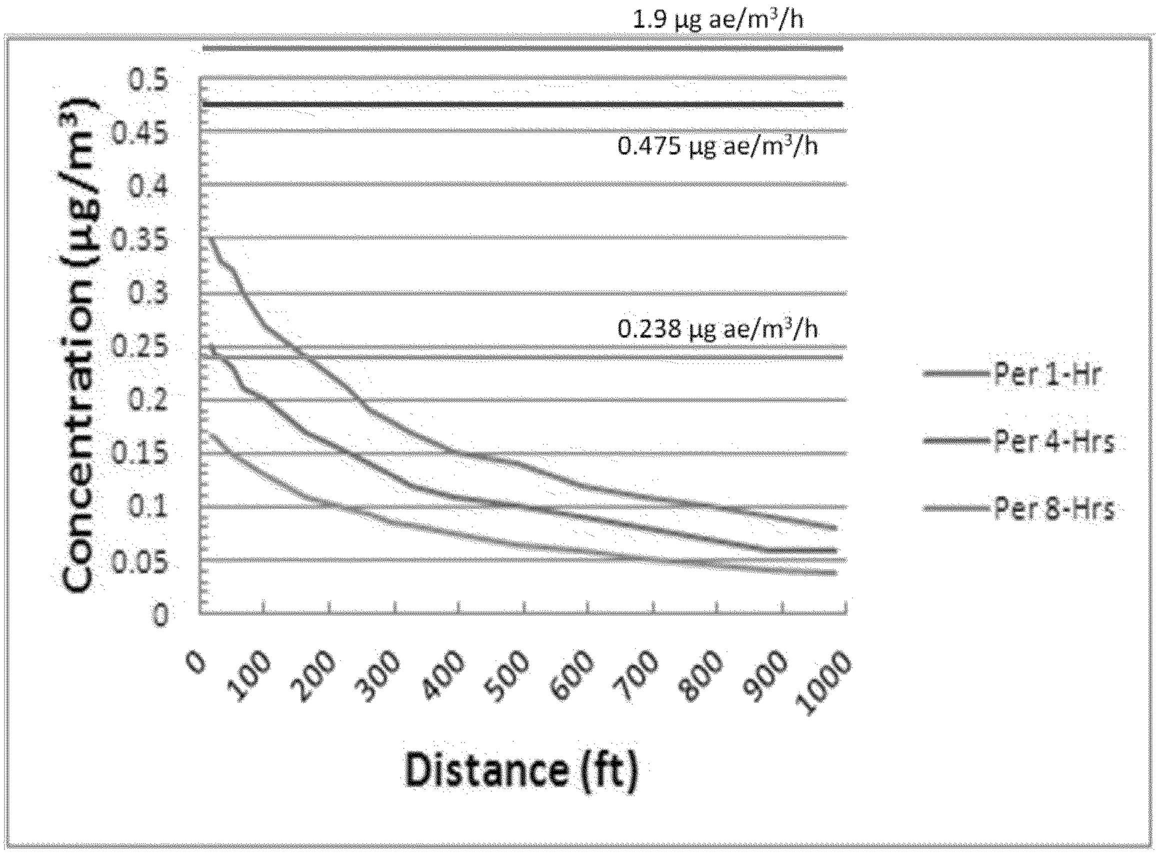
Soybean	52%	Height/Yield	Kelley et al. 2005

Information regarding the effects of vapor phase 2,4-D on grapes and cotton was also contained within the vapor-flux study (MRID 48862902). In this study, fields were treated with a 2,4-D choline salt formulation at an application rate of 5 lb ae/A. Plants were placed near a series of air monitoring stations approximately 1 hour after the herbicide was applied; this ensured that all of the effects were the result of vapor-phase exposures rather than spray drift. Air monitoring stations were set at 5 and 15 m beyond the field's edge and several sets were located along each side of the field to capture air concentrations that differed as a result of wind direction. Plants were also placed directly on the field; no air monitoring station was associated with these plants. Plants were left in the field for 3 days after treatment and then removed to a greenhouse where they were observed for 27 days. Phytotoxic effects (qualitative) were scored on a scale of 0 (no damage) to 100% (dead plant) and compared with controls. The only plants to show outward signs of damage were the grape (0.6% damage) and cotton (40% damage) plants located directly on the field. This study suggests that at 5 m from the edge of the field, plants do not sustain damage from the revolatilization of 2,4-D choline salt on the treated field.

Considering the results from the plant damage studies, the vapor-flux study, and the laboratory vapor-phase study, a conservative approach was taken in selecting endpoints to characterize risk from vapor-phase transport. At 20% physical damage, the grape had the lowest damage rate that resulted in statistically significant reductions in yield/growth. Grape was also the most sensitive species tested in the laboratory vapor-phase study. Using the percent of visual injury for grape, an endpoint of 1.9 µg ae/m^3 per hour was visually identified as the concentration that produced 20% physical damage.

The PERFUM model was used to estimate the off-field distances for various concentrations of 2,4-D as predicted from the vapor flux data (see Section 3.2.4 for more detail). Plant endpoints were selected based on three possible exposure periods: 1 hour, 4 hours, and 8 hours. These durations were selected based on the data in the vapor-phase study (see above). To achieve a concentration of 1.9 µg ai/m^3 per hour in one hour, the atmospheric concentration of 2,4-D would need to be 1.9 µg ai/m^3 per hour. To achieve the same concentration over a 4 hour period, the concentration of 2,4-D would need to be 0.475 µg ai/m^3 per hour (1.9 / 4 hours). Likewise, the air concentration for an 8 hour exposure period is 0.238 µg ai/m^3 per hour (1.9 / 8 hours). The following graph (Figure 4) shows the vapor phase curves for the three different exposure durations. Horizontal lines mark the endpoint (1 hour = 1.9; 4 hours = 0.475; and 8 hours = 0.238 µg ai/m^3 per hour). The model predicts no adverse damage to plants off-field for any of the exposure scenarios.

Figure 4. Vapor Phase Curves for Various Exposure Durations of 2,4-D



The risk quotient analysis indicates there may be risks to terrestrial plants from runoff and spray drift; however, the proposed 2,4-D choline salt formulations for registration are reported to maintain some properties that may reduce spray drift to non-target areas. While EFED has received some information regarding these properties, the full suite of data necessary to analyze these properties is not available. Given that these data and other potential mitigation options are not finalized, EFED has determined that insufficient information is available to make an effects call for direct and indirect effects to terrestrial plants.

5.2.6 Risks to Aquatic Plants

Aquatic vascular and non-vascular plants yielded risk quotients below the LOC for 2,4-D. Risks from 2,4-DCP were dismissed as a preliminary scan of the open literature indicates it is less toxic to vascular and non-vascular plants than 2,4-D. Based on the risk quotient analysis, direct risks to aquatic plants are not expected.

The proposed 2,4-D choline salt formulations for registration are reported to maintain some properties that may reduce spray drift to non-target areas. While EFED has received some information regarding these properties, the full suite of data necessary to analyze these properties is not available. Given that these data and other potential mitigation options are not finalized, EFED has determined that insufficient information is available to make an effects call for indirect effects to aquatic plants.

5.3 Listed Species Assessment

The screening-level analysis for 2,4-D choline salt indicated that there was insufficient information to determine if there were direct effects to mammals (acute and chronic); birds, reptiles, and land-phase amphibians (acute); and terrestrial plants. Indirect effects are determined by assessing the potential for reduction of prey base or habitat modification of listed taxa; however, there was insufficient information to determine if there were indirect effects to any taxa (Table 32).

Table 32. Listed Species Risks Associated with the Proposed New Uses for 2,4-D Choline Salt

Listed Taxa	Direct Effects	Indirect Effects[1]
Terrestrial and semi-aquatic plants: Monocots Dicots	 Insufficient information Insufficient information	 Insufficient information Insufficient information
Birds	Insufficient information – Acute No – Chronic	Insufficient information
Terrestrial-phase amphibians[2]	Insufficient information – Acute No – Chronic	Insufficient information
Reptiles[2]	Insufficient information – Acute No – Chronic	Insufficient information
Mammals	Insufficient information – Acute Insufficient information – Chronic	Insufficient information
Aquatic plants: Vascular Non-vascular	 No No	 Insufficient information Insufficient information
Freshwater fish	No – Acute No – Chronic	Insufficient information
Aquatic-phase amphibians[3]	No – Acute No – Chronic	Insufficient information
Freshwater invertebrates	No – Acute No – Chronic	Insufficient information
Mollusks	No – Acute No – Chronic	Insufficient information
Marine/estuarine fish	No – Acute No – Chronic	Insufficient information

Listed Taxa	Direct Effects	Indirect Effects[1]
Marine/estuarine invertebrates	No – Acute No – Chronic	Insufficient information
Terrestrial invertebrates	No	Insufficient information
[1]Indirect effects to a listed species occur when its prey base is reduced or habitat is modified; indirect effects are assumed for all taxa based on potential effects to terrestrial plants and obligate relationships with birds and/or mammals. [2]Birds are surrogates for reptiles and terrestrial-phase amphibians. [3]Freshwater fish are surrogates for aquatic-phase amphibians.		

5.3.1 Data Gaps and Uncertainties

Avian Acute Oral Toxicity Test for Passerines (850.2100): Data are required for one passerine species when a chemical is intended for outdoor use. The current method of calculating a weight-adjusted LD_{50} using bobwhite quail or mallard duck data may over- or under-estimate risks to passerines because these birds may metabolize the chemical differently. A protocol for the study should be submitted to EPA for approval prior to study initiation. This study has also been identified as a gap in the 2,4-D Problem Formulation (USEPA 2012, D402410).

Estuarine/Marine Invertebrate Chronic Toxicity Test (850.1350): No acceptable data are available for the chronic toxicity of 2,4-D choline salt to marine/estuarine invertebrates. Currently, the toxicological effects for estuarine/marine invertebrates on a chronic basis remain unknown for 2,4-D choline salt, although this assessment estimated a chronic value based on an acute-to-chronic ratio using freshwater invertebrate data. The 2,4-D Problem Formulation identifies this as a gap, but concludes that chronic effects are unlikely, given the degradation rate of 2,4-D acid in water (USEPA 2012, D402410). The acute-to-chronic ratio method was considered valid and protective in lieu of actual data.

Terrestrial Plant Seedling Emergence and Vegetative Vigor Tests (850.4100, 850.4150): Typical end-use data are required for terrestrial plants. In the case of the new 2,4-D choline salt registrations, no information is available for the two 2,4-D choline salt formulations, nor the Enlist™ formulation, which is a mixture with glyphosate. For the 2,4-D choline salt-glyphosate formulation, it is anticipated that there could be additive, synergistic, or interference between the two herbicides, which could cause increased or decreased toxicological effects than are predicted by single ai data. In lieu of these data, toxicity information from other 2,4-D formulations was used as a surrogate; however these surrogates did not contain glyphosate. This represents a point of uncertainty regarding the effects to terrestrial plants in the current analysis.

Terrestrial Plant Vegetative Vigor Test with Vapor Phase Exposure (non-guideline): 2,4-D is known to volatilize from the field and drift off site under certain environmental conditions. EFED evaluated a vapor-phase study on grapes, cotton, soybean, and tomato;

however, the methodology did not include a control, did not measure growth/weight parameters, and was not well-aligned with the 850.4150 protocol. As such, the results from the current vapor-phase study are of very limited value; however, they represent the best information available at the time the risk assessment was prepared. Thus, the data were used in the risk description section to characterize potential risk from 2,4-D vapor coming off of fields. A vapor-phase study with vegetative vigor endpoints is being recommended to further characterize the risk to plants from this exposure route.

Additionally, the following uncertainties were identified for this risk assessment:

- For terrestrial organisms, only dietary exposure to 2,4-D choline salt was assessed.

- The studies with vapor-phase data yielded opposite conclusions regarding the potential for effects to terrestrial plants. Neither study measured quantitative endpoints and the laboratory study did not use a control. There remains uncertainty regarding the effects of vapor-phase exposures on non-target plants.

- For freshwater fish, birds, and terrestrial insects, definitive acute toxicity data were not available. Acute data were presented as greater than values, making it possible to conservatively compare the toxicity value directly to the EECs to estimate potential risk.

- For terrestrial plants, vegetative vigor toxicity values for monocots were non-definitive. The EC_{25} (a greater than value) was compared directly to the EECs to assess the likelihood of risk. The monocot vegetative vigor NOAEC was a less than value; however, given that in dicots, seedling emergence data were more sensitive than the vegetative vigor data, the same pattern was assumed to hold true for monocots. Consequently, the monocot seedling emergence NOAEC was assumed to be the most sensitive monocot NOAEC and used to calculate risk quotients. If this assumption was false, then the analysis may have under-estimated the risk to listed monocots.

- In the absence of chronic data for marine/estuarine invertebrates, an acute-to-chronic ratio was calculated to estimate the NOAEC for Eastern oyster.

- This risk assessment only considered the most sensitive of the species evaluated in the registrant-submitted studies. The position of the tested species relative to the distribution of all species' sensitivities to 2,4-D choline salt is unknown. Extrapolating the risk conclusions from the most sensitive tested species to non-tested species may either underestimate or overestimate the potential risks to those species.

- 2,4-D is currently undergoing a Tier I Endocrine Disruptor Screening as required by FFDCA section 408(p). The results of the screening analysis are not yet available.

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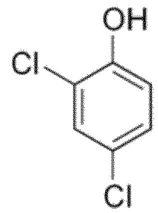
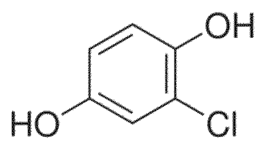
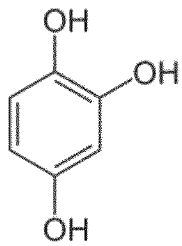
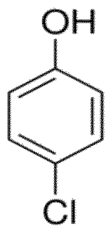
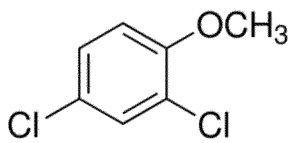
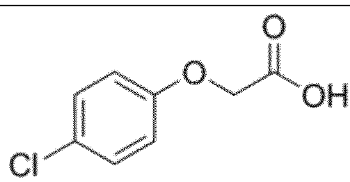
Appendix A. Registrations and Uses for 2,4-D Choline Salt					
Use	**Max. Single App. Rate (lbs ae/A)**	**Max. No. of App. per Year**	**Min. Reapp. Interval (d)**	**Max. Annual App. Rate (lbs ae/A)**	**App. Method**
Cereal grains	1.25	1 post-emergence 1 preharvest	NS [A]	1.75	Ground or aerial spray Broadcast
Field corn and pop corn	1 (preplant or preemergence) 0.5 (postemergence) 1.5 (preharvest) (3 total)	1 application per crop stage	NS	3	Ground or aerial spray Broadcast Directed band
Sweet corn	1 (preplant or preemergence) 0.5 (post emergence) (1.5 total)	1 application per crop stage	21	1.5	Ground or aerial spray Broadcast Directed band
Grain or forage sorghum	1 (amines, acid, salts) 0.5 (esters) (1.5 total)	1	NR[B]	1 (amines, acid, salts) 0.5 (esters)	Ground or aerial spray Broadcast Directed band
Soybeans	1	1	NR	1	Ground or aerial spray Broadcast
Sugarcane	2 (preemergence) 2 (postemergence) (4 total)	1 application per crop stage	NS	4	Ground or aerial spray Broadcast or band
Rice	1 (preplant) 1.5 (postemergence) (2.5 total)	1 application per crop stage	NS	1.5	Ground or aerial spray Broadcast or spot treatment
Pome fruits	2	2	75	4	Broadcast ground or spot treatment
Stone fruits	2	2	75	4	Broadcast ground or spot treatment
Nut orchards, pistachios	2	2	30	4	Broadcast ground or spot treatment
Established grass pastures, rangeland, and perennial grasslands not in agricultural	2	2	30	4	Ground or aerial spray Broadcast or spot

Appendix A. Registrations and Uses for 2,4-D Choline Salt					
Use	**Max. Single App. Rate (lbs ae/A)**	**Max. No. of App. per Year**	**Min. Reapp. Interval (d)**	**Max. Annual App. Rate (lbs ae/A)**	**App. Method**
production					
Ornamental turf	1.5	2	NS	3	Broadcast ground or spot treatment
Grass (turf) grown for seed and sod	2	2	21	4	Broadcast ground or spot treatment
Fallow land and crop stubble	2	2	30	4	Ground or aerial spray Broadcast
Forest site preparation, forest roadsides, brush control, established conifer release	4	1	NR	4	Ground or aerial spray Broadcast
Tree and brush control	8 lb ai/100 gal (basal spray, cut surface – stumps, frill) 2 ml of 4 lb ae/injection site (injection)	1	NR	4 (broadcast only)	Ground or aerial spray Broadcast, spot, basal, frill, cut stump or injection
Non-cropland	4	2	30	4	Ground or aerial spray Broadcast or spot
Aquatic weed control (irrigation ditch bank application)	2	2	30 (broadcast only)	4	Boat or aerial spray Broadcast or spot
Aquatic weed control (surface application for floating and emergent weeds)	4	2	21 (broadcast only)	8	Boat or aerial spray Broadcast or spot
Aquatic weed control (surface application or subsurface injection for submersed weeds)	4 ppm ae/A (10.8 lb ae/Acre foot)	2	21	10.8 lb ae/Acre foot	Boat or aerial spray Broadcast or spot

[A] NS means "not stated."
[B] NR means "not relevant."

Appendix B. Major and Minor Degradates Identified in Environmental Fate Studies			
Chemical Name (CAS No.)	**Molecular Formula Molecular wt.: g/mole**	**Chemical Structure**	**Maximum Formed**
2,4-Dichlorophenol [2,4-DCP] (120-83-2)	$C_6H_4Cl_2O$ 163.0		32.6 % of applied in Anaerobic aquatic study
Chlorohydroquinone [CHQ] (615-67-8)	$C_6H_3(OH)_2Cl$ 144.56		16.0 % of applied in aerobic aquatic study
1,2,4-benezenetriol (533-73-3)	$C_6H_6O_3$ 126.11		37.0% formed of applied in aquatic photo-degradation study
4-chlorophenol (106-48-9)	C_6H_5ClO 128.56		<2.0% formed of applied in anaerobic aquatic metabolism study [Intermediate degradate]
2,4-dichloroanisol [2,4-DCA] (553-82-2)	$C_7H_6Cl_2O$ 177.03		<2.0% formed of applied in aerobic soil metabolism study
4-Chlorophenoxyacetic acid [4-CPA] (122-88-3)	C_8H_7ClO 186.59		<2.0% formed of applied in anaerobic aquatic metabolism study

Appendix C. SIP and STIR Results for 2,4-D Choline Salt

SIP

Table 1. Inputs

Parameter	Value
Chemical name	2,4-D choline salt
Solubility (in water at 25°C; mg/L)	569
Mammalian LD_{50} (mg/kg -bw)	441
Mammalian test species	laboratory rat
Body weight (g) of "other" mammalian species	
Mammalian NOAEL (mg/kg-bw)	5
Mammalian test species	laboratory rat
Body weight (g) of "other" mammalian species	
Avian LD_{50} (mg/kg-bw)	218.7
Avian test species	northern bobwhite quail
Body weight (g) of "other" avian species	
Mineau scaling factor	1.15
Mallard NOAEC (mg/kg-diet)	
Bobwhite quail NOAEC (mg/kg-diet)	962
NOAEC (mg/kg-diet) for other bird species	
Body weight (g) of other avian species	
NOAEC (mg/kg-diet) for 2nd other bird species	
Body weight (g) of 2nd other avian species	

Table 2. Mammalian Results

Parameter	Acute	Chronic
Upper bound exposure (mg/kg-bw)	97.8680	97.8680
Adjusted toxicity value (mg/kg-bw)	339.1998	3.8458
Ratio of exposure to toxicity	0.2885	25.4480
Conclusion*	**Exposure through drinking water alone is a potential concern for mammals**	**Exposure through drinking water alone is a potential concern for mammals**

Table 3. Avian Results

Parameter	Acute	Chronic
Upper bound exposure (mg/kg-bw)	460.8900	460.8900
Adjusted toxicity value (mg/kg-bw)	157.5579	102.2590
Ratio of exposure to acute toxicity	2.9252	4.5071
Conclusion*	**Exposure through drinking water alone is a potential concern for birds**	**Exposure through drinking water alone is a potential concern for birds**

*Conclusion is for drinking water exposure alone. This does not combine all routes of exposure. Therefore, when aggregated with other routes (*i.e.*, diet, inhalation, dermal), pesticide exposure through drinking water may contribute to a total exposure that has potential for effects to non-target animals.

STIR

Input		
Application and Chemical Information		
Enter Chemical Name	2,4-D Choline salt	
Enter Chemical Use	herbicide	
Is the Application a Spray? (enter y or n)	y	
If Spray What Type (enter ground or air)	air	
Enter Chemical Molecular Weight (g/mole)	324.7	
Enter Chemical Vapor Pressure (mmHg)	1.40E-07	
Enter Application Rate (lb a.i./acre)	1	
Toxicity Properties		
Bird		
Enter Lowest Bird Oral LD_{50} (mg/kg bw)	218.7	
Enter Mineau Scaling Factor	1.15	
Enter Tested Bird Weight (kg)	0.178	
Mammal		
Enter Lowest Rat Oral LD_{50} (mg/kg bw)	441	
Enter Lowest Rat Inhalation LC_{50} (mg/L)	0.78	
Duration of Rat Inhalation Study (hrs)	4	
Enter Rat Weight (kg)	0.35	
Output		
Results Avian (0.020 kg)		
Maximum Vapor Concentration in Air at Saturation (mg/m^3)	2.45E-03	
Maximum 1-hour Vapor Inhalation Dose (mg/kg)	3.08E-04	
Adjusted Inhalation LD_{50}	2.16E+00	
Ratio of Vapor Dose to Adjusted Inhalation LD_{50}	1.43E-04	**Exposure not Likely Significant**
Maximum Post-treatment Spray Inhalation Dose	9.61E-02	

(mg/kg)		
Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}	4.45E-02	Exposure not Likely Significant
Results Mammalian (0.015 kg)		
Maximum Vapor Concentration in Air at Saturation (mg/m^3)	2.45E-03	
Maximum 1-hour Vapor Inhalation Dose (mg/kg)	3.87E-04	
Adjusted Inhalation LD_{50}	4.64E+01	
Ratio of Vapor Dose to Adjusted Inhalation LD_{50}	8.32E-06	Exposure not Likely Significant
Maximum Post-treatment Spray Inhalation Dose (mg/kg)	1.21E-01	
Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}	2.60E-03	Exposure not Likely Significant

Appendix D. Examples of PRZM/EXAMS Outputs for 2,4-D and 2,4-DCP

2,4-D

stored as MSCornAT1.out
Chemical: 2 4 D choline
PRZM environment: MScornSTD.txt; modified Tueday, 29 May 2007 at 13:57:40
EXAMS environment: pond298.exv;modified Tueday, 26 August 2008 at 06:14:08
Metfile: w03940.dvf;modified Tueday, 26 August 2008 at 06:14:14

Water segment concentrations (ppb)

Year	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
1961	16.9	15.9	14.0	10.3	8.1	2.3
1962	48.0	46.1	37.3	24.1	18.4	5.0
1963	4.9	4.6	4.1	2.8	2.2	0.6
1964	30.5	28.1	23.6	16.4	12.1	3.2
1965	38.6	37.0	28.9	17.8	13.1	3.4
1966	10.6	9.8	7.4	4.7	3.6	1.0
1967	12.7	11.8	9.4	6.3	4.8	1.3
1968	13.4	12.9	10.9	8.7	6.6	1.8
1969	13.4	12.5	10.6	6.8	5.0	1.4
1970	6.0	5.6	4.3	3.5	2.7	0.7
1971	49.3	46.2	36.9	22.7	17.3	4.8
1972	5.4	5.1	4.0	2.8	2.3	0.6
1973	29.1	27.7	23.5	14.7	11.0	3.0
1974	38.4	35.7	31.8	20.1	14.8	4.0
1975	9.7	9.1	7.3	5.4	4.4	1.2
1976	33.8	31.6	25.1	17.7	13.5	3.7
1977	15.8	14.8	13.4	10.1	7.5	2.0
1978	7.3	6.9	6.2	4.8	3.7	1.0
1979	93.4	88.6	75.4	50.6	38.9	10.8
1980	98.3	94.1	83.9	61.1	48.9	13.6
1981	10.8	10.1	8.8	5.9	4.4	1.2
1982	10.4	9.7	8.6	5.5	4.2	1.2
1983	58.9	54.9	42.1	26.7	20.1	5.4
1984	9.8	9.2	8.3	6.7	5.1	1.4
1985	8.9	8.5	6.8	5.5	4.2	1.1
1986	3.3	3.1	2.7	1.9	1.5	0.4
1987	4.1	3.8	3.2	2.7	2.2	0.6
1988	38.5	36.2	28.4	22.4	17.6	4.8
1989	18.4	17.2	14.5	11.7	9.2	2.5
1990	11.7	11.0	8.5	5.2	4.0	1.1

Sorted results

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.03	98.27	94.09	83.86	61.11	48.91	13.55
0.06	93.43	88.55	75.44	50.64	38.87	10.83
0.10	58.93	54.93	42.07	26.65	20.08	5.38
0.13	49.28	46.21	37.29	24.05	18.36	4.98
0.16	48.03	46.11	36.94	22.69	17.61	4.85
0.19	38.64	36.99	31.77	22.35	17.25	4.77
0.23	38.50	36.23	28.93	20.14	14.81	3.97
0.26	38.40	35.70	28.36	17.80	13.50	3.66
0.29	33.75	31.55	25.10	17.66	13.05	3.44
0.32	30.52	28.12	23.59	16.39	12.14	3.19
0.35	29.13	27.74	23.51	14.69	10.99	2.98
0.39	18.37	17.22	14.52	11.67	9.16	2.51
0.42	16.85	15.89	14.01	10.32	8.08	2.27
0.45	15.81	14.79	13.43	10.05	7.52	2.00
0.48	13.42	12.86	10.90	8.68	6.57	1.76
0.52	13.36	12.52	10.58	6.79	5.12	1.39
0.55	12.67	11.77	9.35	6.70	5.02	1.35
0.58	11.67	10.95	8.82	6.33	4.83	1.33
0.61	10.75	10.13	8.65	5.92	4.44	1.24
0.65	10.57	9.76	8.50	5.53	4.42	1.22
0.68	10.36	9.66	8.31	5.49	4.25	1.18
0.71	9.83	9.20	7.40	5.41	4.23	1.14
0.74	9.67	9.14	7.28	5.22	4.02	1.13
0.77	8.86	8.46	6.79	4.82	3.67	1.01
0.81	7.34	6.90	6.23	4.73	3.56	0.99
0.84	5.97	5.58	4.34	3.47	2.66	0.74
0.87	5.38	5.05	4.06	2.84	2.26	0.65
0.90	4.95	4.62	4.02	2.83	2.20	0.62
0.94	4.07	3.83	3.19	2.66	2.18	0.60
0.97	3.28	3.08	2.75	1.94	1.53	0.42
0.10	57.97	54.06	41.59	26.39	19.91	5.34
					Average of yearly averages :	2.84

Inputs generated by pe5.pl - Novemeber 2006

Data used for this run:
Output File: MSCornAT1
Metfile: w03940.dvf
PRZM scenario: MScornSTD.txt

EXAMS environment file:	pond298.exv			
Chemical Name:	2 4 D choline			
Description	Variable Name	Value	Units	Comments
Molecular weight	mwt	221.4	g/mol	
Henry's Law Const.	henry	8.56E-06	atm-m^3/mol	
Vapor Pressure	vapr	1.40E-07	torr	
Solubility	sol	569	mg/L	
Kd	Kd		mg/L	
Koc	Koc	61.7	mg/L	
Photolysis half-life	kdp	13	days	Half-life
Aerobic Aquatic Metabolism	kbacw	45	days	Halfife
Anaerobic Aquatic Metabolism	kbacs	321	days	Halfife
Aerobic Soil Metabolism	asm	6.9	days	Halfife
Hydrolysis:	pH 7	0	days	Half-life
Method:	CAM	2	integer	See PRZM manual
Incorporation Depth:	DEPI		cm	
Application Rate:	TAPP	1.12	kg/ha	
Application Efficiency:	APPEFF	0.99	fraction	
Spray Drift	DRFT	0.017	fraction of application rate applied to pond	

Application Date	Date	29-03	dd/mm or dd/mmm or dd-mm or dd-mmm	
Interval 1	interval	12	days	Set to 0 or delete line for single app.
app. rate 1	apprate		kg/ha	
Interval 2	interval	12	days	Set to 0 or delete line for single app.
app. rate 2	apprate		kg/ha	
Record 17:	FILTRA			
	IPSCND	1		
	UPTKF			
Record 18:	PLVKRT	0.079		
	PLDKRT			
	FEXTRC	0.5		
Flag for Index Res. Run	IR	EPA Pond		
Flag for runoff calc.	RUNOFF	none	none, monthly or total(average of entire run)	

Pre Process 2,4-DCP PRZM/EXAMS Outputs for Terrestrial and Spray Drift

date	Terrestrial EEC	Spray Drift EEC	Percent Terr	Percent Spray Drift	% Treated	Adjusted EEC
1/1/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/2/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/3/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/4/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/5/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/6/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/7/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/8/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/9/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/10/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/11/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/12/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/13/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/14/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/15/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
1/16/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00

1/17/1961	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	0.00E+00
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12/27/1990	7.18E-05	2.26E-04	1.00E+00	1.00E+00	1.00E+00	2.98E-04
12/28/1990	7.12E-05	2.24E-04	1.00E+00	1.00E+00	1.00E+00	2.95E-04
12/29/1990	7.06E-05	2.22E-04	1.00E+00	1.00E+00	1.00E+00	2.93E-04
12/30/1990	7.00E-05	2.20E-04	1.00E+00	1.00E+00	1.00E+00	2.90E-04
12/31/1990	6.94E-05	2.19E-04	1.00E+00	1.00E+00	1.00E+00	2.88E-04
1/1/1991	6.89E-05	2.17E-04	1.00E+00	1.00E+00	1.00E+00	2.86E-04

Post Process 2,4-DCP PRZM/EXAMS Outputs for Terrestrial and Spray Drift Outputs

Year	Max Peak	4-day	Max 14 day	Max 21 day	Max 30 day	Max 60 day	Max 90 day	Annual
2.0E+03	3.7E-03	3.5E-03	3.1E-03	3.0E-03	2.8E-03	2.5E-03	2.1E-03	1.1E-03
2.0E+03	4.4E-03	4.3E-03	3.9E-03	3.7E-03	3.6E-03	3.0E-03	2.5E-03	1.1E-03
2.0E+03	3.7E-03	3.6E-03	3.1E-03	2.9E-03	2.8E-03	2.3E-03	2.0E-03	9.3E-04
2.0E+03	4.2E-03	4.0E-03	3.7E-03	3.5E-03	3.3E-03	2.7E-03	2.3E-03	9.3E-04
2.0E+03	3.7E-03	3.6E-03	3.1E-03	2.9E-03	2.8E-03	2.3E-03	2.0E-03	8.4E-04
2.0E+03	3.8E-03	3.6E-03	3.3E-03	3.0E-03	2.8E-03	2.5E-03	2.1E-03	8.7E-04
2.0E+03	3.5E-03	3.4E-03	3.2E-03	3.2E-03	3.0E-03	2.6E-03	2.2E-03	9.0E-04
2.0E+03	3.8E-03	3.6E-03	3.3E-03	3.1E-03	3.0E-03	2.5E-03	2.2E-03	8.8E-04
2.0E+03	4.4E-03	4.2E-03	3.7E-03	3.5E-03	3.3E-03	2.7E-03	2.2E-03	8.9E-04
2.0E+03	3.6E-03	3.4E-03	3.0E-03	2.8E-03	2.7E-03	2.3E-03	1.9E-03	9.4E-04
2.0E+03	4.6E-03	4.4E-03	4.0E-03	3.8E-03	3.6E-03	3.0E-03	2.5E-03	1.0E-03
2.0E+03	3.5E-03	3.4E-03	3.1E-03	2.9E-03	2.7E-03	2.4E-03	2.0E-03	9.0E-04
2.0E+03	4.5E-03	4.4E-03	3.9E-03	3.7E-03	3.5E-03	2.9E-03	2.4E-03	9.5E-04
2.0E+03	4.4E-03	4.2E-03	3.7E-03	3.5E-03	3.3E-03	2.7E-03	2.3E-03	9.1E-04
2.0E+03	3.6E-03	3.5E-03	3.3E-03	3.2E-03	3.0E-03	2.6E-03	2.2E-03	9.6E-04
2.0E+03	3.9E-03	3.8E-03	3.4E-03	3.2E-03	3.1E-03	2.8E-03	2.5E-03	1.1E-03
2.0E+03	4.2E-03	4.0E-03	3.6E-03	3.3E-03	3.2E-03	2.6E-03	2.2E-03	9.8E-04
2.0E+03	3.8E-03	3.6E-03	3.3E-03	3.2E-03	3.0E-03	2.6E-03	2.3E-03	1.2E-03
2.0E+03	5.6E-03	5.5E-03	5.0E-03	4.8E-03	4.7E-03	4.0E-03	3.4E-03	1.5E-03
2.0E+03	5.7E-03	5.6E-03	5.3E-03	5.0E-03	4.9E-03	4.2E-03	3.6E-03	1.5E-03
2.0E+03	3.8E-03	3.6E-03	3.2E-03	3.0E-03	2.9E-03	2.5E-03	2.2E-03	1.2E-03
2.0E+03	4.2E-03	4.0E-03	3.6E-03	3.3E-03	3.1E-03	2.5E-03	2.2E-03	1.1E-03
2.0E+03	5.0E-03	4.7E-03	4.2E-03	4.1E-03	3.9E-03	3.4E-03	2.9E-03	1.2E-03
2.0E+03	3.8E-03	3.6E-03	3.3E-03	3.1E-03	2.9E-03	2.5E-03	2.1E-03	9.5E-04
2.0E+03	3.6E-03	3.5E-03	3.1E-03	2.9E-03	2.8E-03	2.3E-03	1.9E-03	8.4E-04
2.0E+03	3.6E-03	3.5E-03	3.1E-03	2.8E-03	2.7E-03	2.4E-03	2.1E-03	9.0E-04
2.0E+03	3.7E-03	3.5E-03	3.2E-03	3.0E-03	2.9E-03	2.4E-03	2.1E-03	9.5E-04
2.0E+03	4.4E-03	4.2E-03	3.8E-03	3.6E-03	3.3E-03	2.8E-03	2.4E-03	1.0E-03
2.0E+03	3.8E-03	3.6E-03	3.4E-03	3.3E-03	3.2E-03	2.8E-03	2.4E-03	1.0E-03
2.0E+03	3.6E-03	3.5E-03	3.3E-03	3.1E-03	2.9E-03	2.6E-03	2.2E-03	1.1E-03
90th % (ppm)	0.00		0.00	0.00	0.00	0.00	0.00	0.00
90th % (ppb)	4.66		4.05	3.84	3.62	3.01	2.55	1.17

Appendix E. Avian and Mammalian Risk Quotient Calculations for 2,4-D Choline Salt Based on T-REX

Applications to herbicide-tolerant soybean and corn at 1 lb ae/A, 3 applications that are 12 days apart

Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted LD50	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
20	0.00	658.79	#DIV/0!	301.94	#DIV/0!	370.57	###	41.17	#DIV/0!	258.03	###	9.15	###
100	0.00	375.67	#DIV/0!	172.18	#DIV/0!	211.31	###	23.48	#DIV/0!	147.14	###	5.22	###
1000	0.00	168.19	#DIV/0!	77.09	#DIV/0!	94.61	###	10.51	#DIV/0!	65.88	###	2.34	###

Upper Bound Kenaga, Subacute Avian Dietary Based Risk Quotients										
	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seed s		Arthropods	
LC5 0	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
0	578.4 4	#DIV/0 !	265.1 2	#DIV/0 !	325.3 7	#DIV/0 !	36.15	#####	226.5 6	#DIV/0 !

Size class not used for dietary risk quotients

Upper Bound Kenaga, Chronic Avian Dietary Based Risk Quotients										
	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seed s		Arthropods	
NOAEC (ppm)	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
962	578.44	0.6 0	265.12	0.2 8	325.37	0.34	36.15	0.04	226.56	0.2 4

Size class not used for dietary risk quotients

Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients		
Size	Adjusted	EECs and RQs

Class (grams)	LD50	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/ Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	969.24	551.50	0.57	252.77	0.26	310.22	0.32	34.47	0.04	216.004	0.2229	7.6597	0.0079
35	784.22	381.16	0.49	174.70	0.22	214.40	0.27	23.82	0.03	149.288	0.1904	5.2939	0.0068
1000	339.20	88.37	0.26	40.50	0.12	49.71	0.15	5.52	0.02	34.6129	0.102	1.2274	0.0036

Upper Bound Kenaga, Acute Mammalian Dietary Based Risk Quotients										
LC50 (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
0	578.44	#DIV/0!	265.12	#DIV/0!	325.37	#DIV/0!	36.15	#####	226.56	#DIV/0!

Size class not used for dietary risk quotients

Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients										
NOAEC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
100	578.44	5.78	265.12	2.65	325.37	3.25	36.15	0.36	226.56	2.27

Size class not used for dietary risk quotients

Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted NOAEL	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/ Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	10.99	551.50	50.19	252.77	23.00	310.22	28.23	34.47	3.14	216.00	19.66	7.66	0.70
35	8.89	381.16	42.87	174.70	19.65	214.40	24.11	23.82	2.68	149.29	16.79	5.29	0.60
1000	3.85	88.37	22.98	40.50	10.53	49.71	12.93	5.52	1.44	34.61	9.00	1.23	0.32

Appendix F. Terrestrial Plant Risk Quotient Calculations for 2,4-D Choline Salt Based on TerrPlant

2,4-D choline salt application to herbicide-tolerant corn and soybean at 1 lb ae/A

Table 1. Chemical Identity.	
Parameter	**User Inputs**
Chemical Name	**2,4-D Choline Salt**
PC code	**52505**
Use	**Herbicide-tolerant corn and soybean**
Application Method	**foliar spray**
Application Form	**liquid**
Solubility in Water (ppm)	**569**

Table 2. Input parameters used to derive EECs.			
Input Parameter	**Symbol**	**Value (user inputs)**	**Units**
Application Rate	A	**1**	
Incorporation	I	**1**	none
Runoff Fraction	R	**0.05**	none
Drift Fraction	D	**0.01**	none

Table 3. EECs for 2,4-D Choline Salt. Units in .		
Description	**Equation**	**EEC**
Runoff to dry areas	(A/I)*R	0.05
Runoff to semi-aquatic areas	(A/I)*R*10	0.5
Spray drift	**A*D**	**0.01**
Total for dry areas	**((A/I)*R)+(A*D)**	**0.06**
Total for semi-aquatic areas	**((A/I)*R*10)+(A*D)**	**0.51**

Table 4. Plant survival and growth data used for RQ derivation. Units are in . All values are user inputs				
	Seedling Emergence		**Vegetative Vigor**	
Plant type	**EC_{25}**	**NOAEC**	**EC_{25}**	**NOAEC**
Monocot	**0.01**	**0.005628**	**x**	**x**
Dicot	**0.00081**	**0.00047**	**0.0021**	**0.00167**

Table 5. RQ values for plants in dry and semi-aquatic areas exposed to 2,4-D Choline Salt through runoff and/or spray drift.*

Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	6.00	51.00	1.00
Monocot	listed	10.66	90.62	1.78
Dicot	non-listed	74.07	629.63	12.35
Dicot	listed	127.66	1085.11	21.28
*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.				

Appendix G. Risk Quotient Method and Levels of Concern

The Risk Quotient Method is the means by which the Environmental Fate and Effects Division (EFED) integrates the results of exposure and ecotoxicity data. In this method, both acute and chronic risk quotients are calculated by dividing exposure estimates by the most sensitive ecotoxicity values derived from the studies. Calculated risk quotients are then compared to OPP's levels of concern. The levels of concern are the criteria used by OPP to indicate potential risk to non-target organisms and the need to consider regulatory action. EFED has defined levels of concern for acute risk, potential restricted use, and for listed species. Risk presumptions, along with the corresponding risk quotients and levels of concern are summarized in the table below.

Table G-1. Levels of Concern for Assessed Taxa

Risk Presumption	Risk Quotient	Level of Concern
Birds		
Acute Risk	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day	0.5
Acute Restricted Use	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day (or LD_{50} < 50 mg/kg)	0.2
Acute Listed Species	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day	0.1
Chronic Risk	EEC/NOAEC	1
Mammals		
Acute Risk	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day	0.5
Acute Restricted Use	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day (or LD_{50} < 50 mg/kg)	0.2
Acute Listed Species	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day	0.1
Chronic Risk	EEC/NOAEC	1
Aquatic Animals		
Acute Risk	EEC/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Listed Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/NOAEC	1
Terrestrial and Semi-Aquatic Plants		
Acute Risk	EEC/EC_{25}	1
Acute Listed Species	EEC/EC_{05} or NOAEC	1

Risk Presumption	Risk Quotient	Level of Concern
Aquatic Plants		
Acute Risk	EEC/EC_{50}	1
Acute Listed Species	EEC/EC_{05} or NOAEC	1

Appendix H: Preliminary Volatility Flux Data

Table X-1. 2,4-D volatility flux rate from soybean at Farmland, IN				
Period[1]	Flux Rate (g/m^2-s)			
	Unadjusted Flux Rate[2]		Adjusted Flux Rate[3]	
	EPA	Registrant	EPA	Registrant
Field 1 (2,4 D choline)				
1	2.20E-08	1.80E-10	5.50E-09	4.50E-11
2	2.90E-10	1.60E-11	7.25E-11	4.00E-12
3	8.30E-12	1.40E-11	2.08E-12	3.50E-12
4	5.80E-12	5.00E-12	1.45E-12	1.25E-12
5	5.10E-10	3.50E-11	1.28E-10	8.75E-12
6	4.80E-11	1.50E-10	1.20E-11	3.75E-11
7	5.90E-10	1.60E-10	1.48E-10	4.00E-11
8	6.00E-11	1.10E-10	1.50E-11	2.75E-11
Field 2 (2,4-D DMA)				
1	6.00E-08	1.30E-08	3.00E-08	6.50E-09
2	1.60E-09	2.50E-11	8.00E-10	1.25E-11
3	2.20E-10	1.20E-10	1.10E-10	6.00E-11
4	8.00E-11	8.40E-11	4.00E-11	4.20E-11
5	1.20E-09	7.00E-10	6.00E-10	3.50E-10
6	1.50E-10	2.60E-10	7.50E-11	1.30E-10
7	3.40E-10	3.50E-10	1.70E-10	1.75E-10
8	1.40E-10	1.50E-10	7.00E-11	7.50E-11
Field 3 (2,4-D EHE)				
1	7.80E-08	7.60E-08	7.80E-08	7.60E-08
2	5.10E-08	4.00E-08	5.10E-08	4.00E-08
3	3.40E-09	5.40E-09	3.40E-09	5.40E-09
4	6.90E-09	2.80E-09	6.90E-09	2.80E-09
5	2.80E-08	2.50E-08	2.80E-08	2.50E-08
6	6.60E-09	2.70E-09	6.60E-09	2.70E-09
7	1.50E-08	4.40E-09	1.50E-08	4.40E-09
8	2.50E-09	3.20E-09	2.50E-09	3.20E-09

[1] = Air Monitoring Period (varies-2 to 11 hours)
[2]Flux rate based on application rate used in study
3 = Flux rate based on 1.0 lb a.e./A

Table X-1. 2,4-D volatility flux rate from Bare field. Fowler, IN				
Period[1]	Flux Rate (g/m2-s)			
	Unadjusted Flux Rate[2]		Adjusted Flux Rate[3]	
	EPA	Registrant	EPA	Registrant

Field 1 (2,4-D Choline)				
1	7.70E-08	2.00E-08	1.53E-08	3.97E-09
2	9.30E-10	1.20E-09	1.85E-10	2.38E-10
3	6.20E-10	1.60E-10	1.23E-10	3.17E-11
4	6.90E-09	3.20E-09	1.37E-09	6.35E-10
5	2.60E-10	2.30E-10	5.16E-11	4.56E-11
6	1.60E-12	4.60E-12	3.17E-13	9.13E-13
7	5.20E-12	2.50E-11	1.03E-12	4.96E-12
8	3.30E-12	2.80E-12	6.55E-13	5.56E-13
Field 2 (2,4-D DMA)				
1	1.20E-07	5.60E-08	4.56E-08	2.13E-08
2	4.00E-09	5.40E-09	1.52E-09	2.05E-09
3	2.60E-10	3.50E-10	9.89E-11	1.33E-10
4	8.50E-09	4.80E-09	3.23E-09	1.83E-09
5	5.30E-10	3.30E-10	2.02E-10	1.25E-10
6	2.10E-12	9.00E-13	7.98E-13	3.42E-13
7	2.00E-11	6.40E-11	7.60E-12	2.43E-11
8	0.00E+00	1.00E-12	---	3.80E-13
Field 3 (2,4-D EHE)				
1	2.50E-08	3.60E-08	2.50E-08	3.60E-08
2	5.20E-09	5.70E-09	5.20E-09	5.70E-09
3	8.50E-10	1.10E-09	8.50E-10	1.10E-09
4	4.80E-09	5.50E-09	4.80E-09	5.50E-09
5	8.10E-09	3.20E-09	8.10E-09	3.20E-09
6	1.40E-09	6.20E-10	1.40E-09	6.20E-10
7	1.30E-09	2.30E-09	1.30E-09	2.30E-09
8	7.80E-11	2.30E-11	7.80E-11	2.30E-11

[1] = Air Monitoring Period (varies -5 to 11 hours)
[2] =Flux rate based on application rate used in study
[3] = Flux rate based on 1.0 lb a.e./A

Table 3. 2,4-D volatility flux rate from soybean at Little Rock, AR

Period[1]	**Flux Rate (g/m2-s)**			
	Unadjusted Flux Rate[2]		**Adjusted Flux Rate**[3]	
	EPA	**Registrant**	**EPA**	**Registrant**
Field 1 (2,4-D Choline)				
1	7.50E-08	1.50E-08	1.88E-08	3.75E-09
2	2.10E-09	2.70E-09	5.25E-10	6.75E-10
3	3.30E-10	4.00E-10	8.25E-11	1.00E-10
4	1.30E-10	1.40E-10	3.25E-11	3.50E-11
5	6.10E-09	6.60E-10	1.53E-09	1.65E-10
6	2.10E-10	2.40E-10	5.25E-11	6.00E-11

Table 3. 2,4-D volatility flux rate from soybean at Little Rock, AR				
Period[1]	Flux Rate (g/m2-s)			
	Unadjusted Flux Rate[2]		Adjusted Flux Rate[3]	
	EPA	Registrant	EPA	Registrant
7	2.00E-10	2.50E-10	5.00E-11	6.25E-11
8	1.20E-10	1.40E+10	3.00E-11	3.50E+09
Field 2 (2,4 D choline plus glyphosate DMA)				
1	2.00E-08	6.00E-08	2.44E-09	7.31E-09
2	3.40E-09	6.00E-09	4.14E-10	7.31E-10
3	4.40E-10	6.40E-10	5.36E-11	7.80E-11
4	1.80E-10	2.00E-10	2.19E-11	2.44E-11
5	3.90E-09	2.30E-09	4.75E-10	2.80E-10
6	1.20E-10	1.60E-10	1.46E-11	1.95E-11
7	3.00E-10	4.20E-10	3.65E-11	5.12E-11
8	9.80E-11	1.50E-10	1.19E-11	1.83E-11
Field 3 (2,4 D DMA)				
1	3.70E-08	3.00E-08	9.02E-08	7.32E-08
2	3.00E-09	4.00E-09	7.32E-09	9.76E-09
3	3.40E-10	6.10E-10	8.29E-10	1.49E-09
4	9.10E-11	1.70E-10	2.22E-10	4.15E-10
5	3.70E-09	6.50E-10	9.02E-09	1.59E-09
6	1.60E-10	1.50E-10	3.90E-10	3.66E-10
7	1.30E-10	1.90E-10	3.17E-10	4.63E-10
8	8.30E-11	9.30E-11	2.02E-10	2.27E-10
Field 4 (2,4 D EHE)				
1	3.50E-08	1.70E-07	8.54E-08	4.15E-07
2	2.60E-08	6.70E-09	6.34E-08	1.63E-08
3	2.60E-09	5.80E-10	6.34E-09	1.41E-09
4	1.20E-09	1.90E-09	2.93E-09	4.63E-09
5	9.60E-09	3.60E-09	2.34E-08	8.78E-09
6	7.20E-09	1.30E-09	1.76E-08	3.17E-09
7	5.80E-10	6.20E-10	1.41E-09	1.51E-09
8	7.30E-10	3.70E-10	1.78E-09	9.02E-10

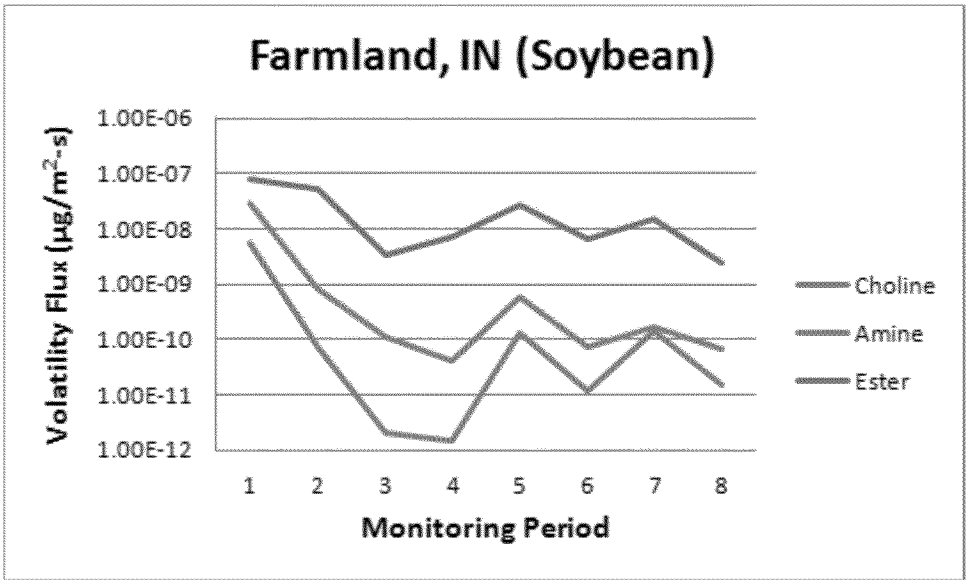
[1] Air Monitoring Period (varies-5 to 11 hours)
[2] = Flux rate based on application rate used in study
[3] = Flux rate based on 1.0 lb a.e./A

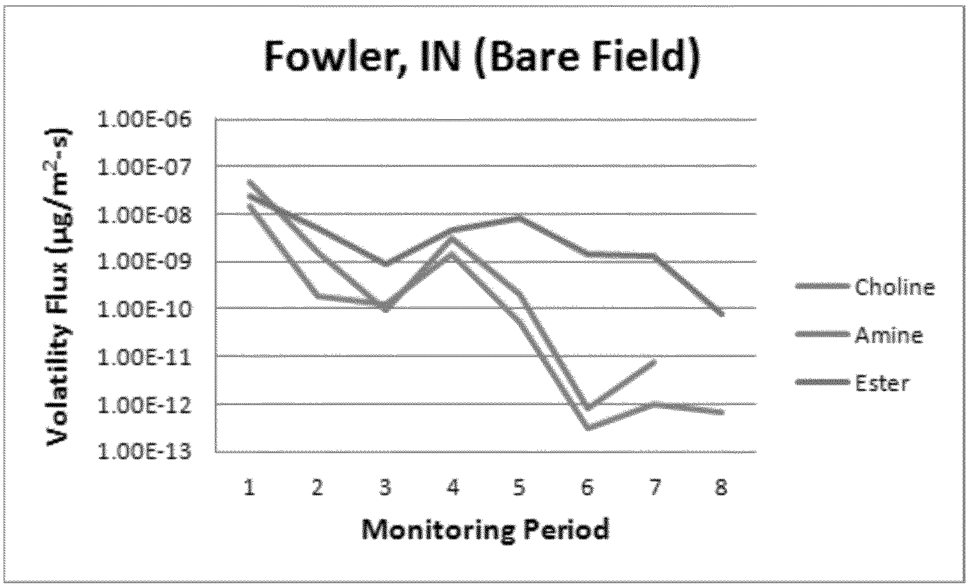
Table 4. 2,4-D volatility flux rate from cotton field at Ty Ty, Ga	
Period[1]	Flux Rate (g/m2-s)

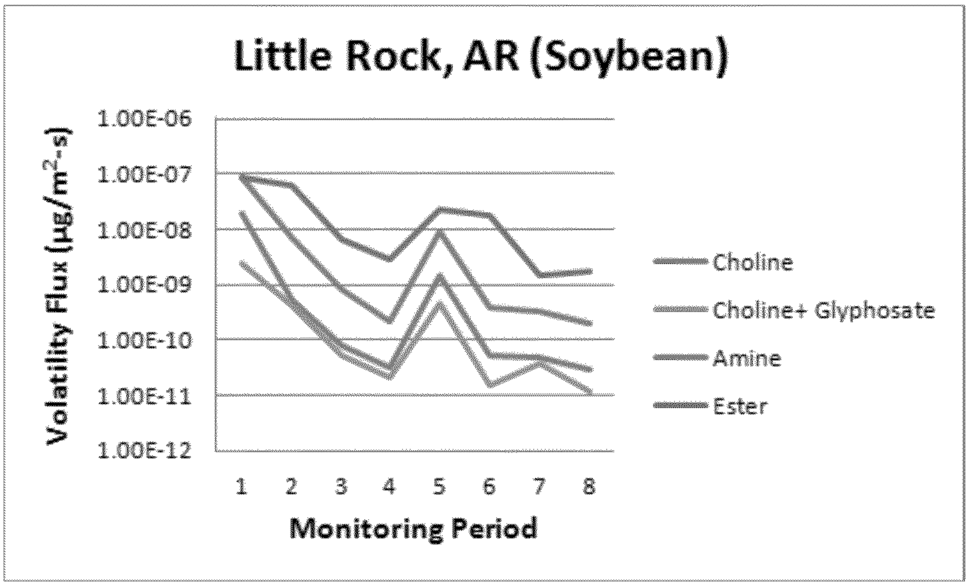
	Unadjusted Flux Rate[2]		Adjusted Flux Rate[3]	
	EPA	Registrant	EPA	Registrant
Field 1 (2,4 D choline plus glyphosate DMA))				
1	1.17E-08	6.00E-10	1.48E-09	7.59E-11
2	2.83E-09	5.00E-09	3.58E-10	6.33E-10
3	1.25E-09	6.00E-10	1.58E-10	7.59E-11
4	3.16E-10	1.00E-10	4.00E-11	1.27E-11
5	4.84E-10	8.00E-10	6.13E-11	1.01E-10
6	1.10E-10	1.00E-10	1.39E-11	1.27E-11
7	2.94E-10	5.00E-10	3.72E-11	6.33E-11
8	9.87E-11	1.00E-10	1.25E-11	1.27E-11
Field 2 (2,4 D choline				
1	1.05E-08	3.00E-09	2.63E-09	7.50E-10
2	1.01E-09	7.00E-10	2.53E-10	1.75E-10
3	3.11E-10	3.00E-11	7.78E-11	7.50E-12
4	1.16E-10	7.50E-11	2.90E-11	1.88E-11
5	5.50E-10	2.00E-10	1.38E-10	5.00E-11
6	2.76E-10	3.50E-11	6.90E-11	8.75E-12
7	5.38E-10	2.50E-10	1.35E-10	6.25E-11
8	8.83E-11	5.50E-11	2.21E-11	1.38E-11
Field 3 (2,4 D DMA)				
1	1.23E-08	1.00E-08	3.00E-08	2.44E-08
2	5.85E-09	1.00E-08	1.43E-08	2.44E-08
3	8.65E-10	3.50E-10	2.11E-09	8.54E-10
4	1.38E-10	1.50E-10	3.37E-10	3.66E-10
5	6.35E-11	3.50E-10	1.55E-10	8.54E-10
6	7.50E-11	7.50E-11	1.83E-10	1.83E-10
7	2.75E-10	4.00E-10	6.71E-10	9.76E-10
8	7.33E-11	8.00E-11	1.79E-10	1.95E-10
Field 4 (2,4 D EHE)				
1	5.88E-09	3.00E-09	1.43E-08	7.32E-09
2	4.29E-08	3.00E-08	1.05E-07	7.32E-08
3	2.05E-08	5.00E-09	5.00E-08	1.22E-08
4	8.10E-09	3.00E-09	1.98E-08	7.32E-09
5	1.38E-08	7.00E-09	3.37E-08	1.71E-08
6	1.39E-09	3.50E-10	3.39E-09	8.54E-10
7	2.02E-09	1.20E-09	4.93E-09	2.93E-09
8	8.50E-10	4.00E-10	2.07E-09	9.76E-10

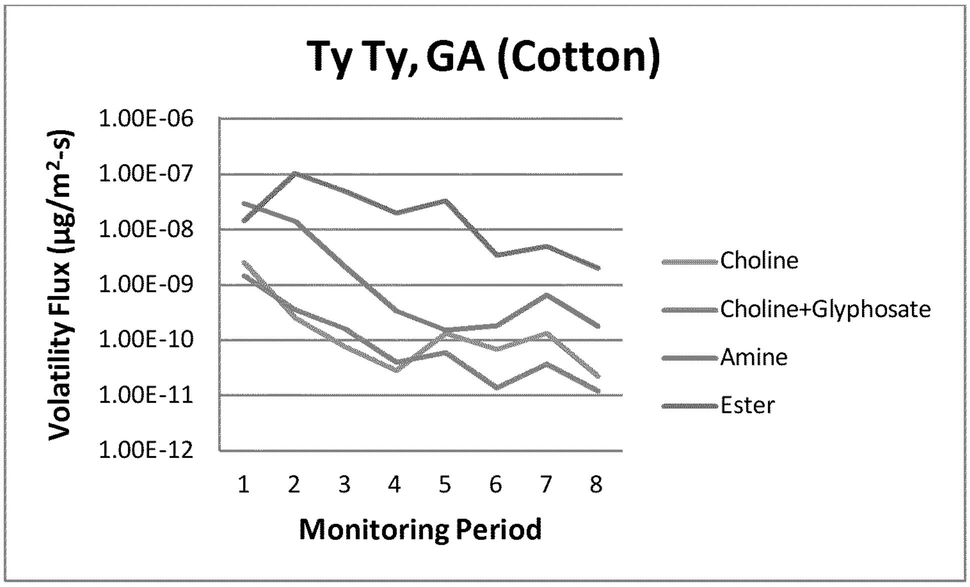
[1] Air Monitoring Period (varies-3 to 13 hours)
[2] = Flux rate based on application rate used in study
[3] = Flux rate based on 1.0 lb a.e./A

Agency Estimated Volatility Flux Profiles of Various 2,4-D Formulations






Little Rock, AR (Soybean)
Volatility Flux (µg/m2-s)
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1 2 3 4 5 6 7 8
Monitoring Period
Choline
Choline+ Glyphosate
Amine
Ester


Ty Ty, GA (Cotton)
Volatility Flux (µg/m2-s)
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1 2 3 4 5 6 7 8
Monitoring Period
Choline
Choline+Glyphosate
Amine
Ester

Appendix I

Example of PERFUM Input and Output

****
** PERFUM Output File
****

Version 2.5.1 - compiled on 7/2/2008
Run finished on: 11/14/2012 at 13:03

****
** Basic information about the model run
****
Scenario Type: GRN

Source of flux data: Application Rate
Source of meteorological data: Peoria, IL
ISCST3 meterologicalfile: ..\PERFUM2\MET\IL14842.MET
Field size (acres): 79.969
Length in x-direction (m): 569.00
Length in y-direction (m): 569.00
Grid density: FINE

****
** Toxicity Inputs
****

Human Equivalent Conc (ug/m3) : 120.0
Uncertainty factor: 1.0
Threshold (ug/m3): 120.0

****
** Exposure Assumptions
****

Exposure averaging period (hours): 1
Distribution averaging time (hours): 1

****
** Time Assumptions
****

Starting year: 1984
Ending year: 1988
Application Start Hour: 7

****
** Additional assumptions for greenhouse scenario

****
Greenhouse source type: Area
Height of greenhouse + stack (m): 0.0
Greenhouse height (m): 0.5
Adjusted greenhouse height (m): 0.5
Source of flux data: Manually entered by user

****
** Fumigant Flux Profiles
****

Flux rates for day number: 1

HOUR	Flux Rate
1	0.032
2	0.032
3	0.032
4	0.032
5	0.032
6	0.032
7	18.800
8	18.800
9	18.800
10	18.800
11	18.800
12	18.800
13	0.525
14	0.525
15	0.525
16	0.525
17	0.525
18	0.525
19	0.082
20	0.082
21	0.082
22	0.082
23	0.082
24	0.082

Flux rates for day number: 2

HOUR	Flux Rate
1	0.052
2	0.052
3	0.052
4	0.052
5	0.052
6	0.052
7	1.530
8	1.530
9	1.530
10	1.530

11	1.530
12	1.530
13	1.530
14	1.530
15	1.530
16	1.530
17	1.530
18	1.530
19	1.530
20	0.052
21	0.052
22	0.052
23	0.052
24	0.052

Flux rates for day number: 3

HOUR	Flux Rate
1	0.030
2	0.030
3	0.030
4	0.030
5	0.030
6	0.030
7	0.050
8	0.050
9	0.050
10	0.050
11	0.050
12	0.050
13	0.050
14	0.050
15	0.050
16	0.050
17	0.050
18	0.050
19	0.050
20	0.030
21	0.030
22	0.030
23	0.030
24	0.030

** All flux rates in micrograms per meter squared per second

----- Number of Periods with Buffer Length Estimates -----

Period	Valid Periods	Calm Periods
1	1694	131
2	1658	167
3	1647	178
4	1639	186

5	1631	194
6	1622	203
7	1615	210
8	1609	216
9	1604	221
10	1597	228
11	1584	241
12	1565	260
13	1517	308
14	1446	379
15	1393	432
16	1357	468
17	1315	510
18	1281	544
19	1243	582
20	1214	611
21	1194	631
22	1172	653
23	1146	679
24	1122	703

*** Due to some large buffers distances, estimates are valid only at or below the following percentiles

Period	Maximum Percentile
1	99.525
2	99.854
3	99.978
4	99.996
5	99.990
6	99.989
7	100.000
8	100.000
9	100.000
10	100.000
11	100.000
12	100.000
13	100.000
14	100.000
15	100.000
16	100.000
17	100.000
18	100.000
19	100.000
20	100.000
21	100.000
22	100.000
23	100.000
24	100.000

------- Definition of Flux Averaging Periods ----------
Period 1: Hours 7 to 7
Period 2: Hours 8 to 8
Period 3: Hours 9 to 9

Period 4: Hours 10 to 10
Period 5: Hours 11 to 11
Period 6: Hours 12 to 12
Period 7: Hours 13 to 13
Period 8: Hours 14 to 14
Period 9: Hours 15 to 15
Period 10: Hours 16 to 16
Period 11: Hours 17 to 17
Period 12: Hours 18 to 18
Period 13: Hours 19 to 19
Period 14: Hours 20 to 20
Period 15: Hours 21 to 21
Period 16: Hours 22 to 22
Period 17: Hours 23 to 23
Period 18: Hours 24 to 24
Period 19: Hours 1 to 1
Period 20: Hours 2 to 2
Period 21: Hours 3 to 3
Period 22: Hours 4 to 4
Period 23: Hours 5 to 5
Period 24: Hours 6 to 6

--------- PERFUM Model Results -----------

Concentration distribution results for rings the field

Ring No.	Distance (meters)
1	5.
2	7.
3	10.
4	15.
5	20.
6	30.
7	50.
8	70.
9	80.
10	90.
11	100.
12	120.
13	150.
14	180.
15	210.
16	240.
17	270.
18	300.
19	360.
20	420.
21	480.
22	540.
23	600.
24	720.
25	840.
26	960.

27 1080.
28 1200.
29 1320.
30 1440.

Table I-1. AERSCREEN Inputs for 2,4-D Air Modeling Runs

Input Parameter	Option/Value
Source Parameters	
Source Type	Area
Maximum Field Emission Rate [1]	Choline Formulation, Corn and Soybean Crops: 1.88×10^{-8} g/m^{2}-s (EPA Value)
Field Size and Dimensions	80 acres (569 meters x 569 meters)
Height of Release	Corn (Choline): 50 cm Soybean (Choline): 15 cm
Land Surface Parameters	
Local Seasonal Characteristics	1 – Midsummer with lush vegetation
Land Surface Characteristics	2 – Agricultural Lands
Albedo	Corn and Soybean Crops: 0.17
Bowen Ratio	Corn and Soybean Crops: 0.4
Aerodynamic Surface Roughness Length	Corn and Soybean Crops: 0.25 m
Geochemical and Resistance Parameters	
Diffusion in Air Coefficient [2]	0.06 cm^{2}/s
Diffusion in Water Coefficient [2]	0.57 cm^{2}/s
Bulk Canopy Cuticular Resistance Parameter [3]	2.08 s/cm
Henry's Law Constant [4]	0.867 Pa·m^{3}/mol
Atmospheric Half-Life [5]	69,732 seconds
Meteorological Parameters	
Wind Speed Range	0.5 - 18 m/s
Hourly Precipitation Amount	2 mm (0.08 inches)
Temperature Range	288K – 311K
Surface Atmospheric Pressure	1013 hPa
Cloud Cover	5/10
Relative Humidity	75%
Output Parameters	
Averaging Period	1-hour
Downwind Distances [6]	0 m – 100 m: Every 10 meters 100 m - 3,000 m: Every 100 meters 3,000 m – 10,000 m: Every 500 meters 10,000 m – 20,000 m Every 5,000 meters
Receptor Height	0 m (Ground-level)

1. Maximum flux rates in field volatility studies scaled to labeled maximum application rate from MRID No. 48862902: EPA maximum identified from 2,4-D Choline formulation corn crops flux rate based on its application to soybeans in Little Rock, AR. 7.50×10^{8} g/m^{2}-s flux rate determined from study at 4.0 lbs. ae/A scaled to value in table at 1 lb. ae/A.
2. Diffusion in air coefficient and diffusion in water coefficient for 2,4-D retrieved from Appendix C of, "AERMOD Deposition Algorithms – Science Document (Revised Draft)", from EPA Office of Air Quality Planning and Standards.
3. Cuticular resistance parameter for 2,4-D retrieved from Appendix D of, "AERMOD

Input Parameter	Option/Value
Deposition Algorithms– Science Document (Revised Draft)", from EPA Office of Air Quality Planning and Standards. 4. Table 8 5. Atmospheric half-life of 2,4-D retrieved from hydroxyl radicals rate constant EpiSuite AOPWIN v. 1.92. 6. Distances referenced from the center of the treated field. The edge of the field is at a downwind distance of 1333.3 feet (402.3 m).	

Example output of AERSCREEN

```
                         AERSCREEN 11076 / AERMOD
         09292                                            11/15/12
                                09:12:09
                             TITLE: soybean
-----------------------------------------------------------------------------
******************************   AREA PARAMETERS   ***************************
-----------------------------------------------------------------------------
   SOURCE EMISSION RATE:        0.609E- 02 g/s            0.483E- 01 lb/hr
AREA EMISSION RATE:           0.188E- 07 g/(s-m2)       0.149E- 06 lb/(hr-m2)
   AREA HEIGHT:                      0.01 meters                0.05 feet
   AREA SOURCE LONG SIDE:          569.00 meters             1866.80 feet
   AREA SOURCE SHORT SIDE:         569.00 meters             1866.80 feet
   INITIAL VERTICAL DIMENSION:       0.00 meters                0.00 feet
                   RURAL OR URBAN:                   RURAL
   INITIAL PROBE DISTANCE =          5000. meters             16404. feet
-----------------------------------------------------------------------------
***********************   BUILDING DOWNWASH PARAMETERS   *********************
-----------------------------------------------------------------------------
             BUILDING DOWNWASH NOT USED FOR NON -POINT SOURCES
-----------------------------------------------------------------------------
**************************  FLOW SECTOR ANALYSIS  ***************************
           25 meter receptor spacing: 1. meters   - 5000. meters
-----------------------------------------------------------------------------
                        MAXIMUM  IMPACT  RECEPTOR
           Zo        SURFACE   1- HR CONC  RADIAL  DIST   TEMPORAL
          SECTOR    ROUGHNESS  (ug/m3)     (deg)   (m)     PERIOD
          ----------------------------------------------------
             1*       0.250     11.28      45   400.0     ANN
                         * = worst case diagonal
-----------------------------------------------------------------------------
*********************  MAKEMET METEOROLOGY PARAMETERS  ********************
-----------------------------------------------------------------------------
                  MIN/MAX TEMPERATURE:    297.0 / 299.0 (K)

                      MINIMUM WIND SPEED:       0.5 m/s
                    ANEMOMETER HEIGHT:     10.000 meters
                SURFACE CHARACTERISTICS INPUT: USER ENTERED
                         ALBEDO:                  0.17
                         BOWEN RATIO:             0.40
                    ROUGHNESS LENGTH:       0.250 (meters)
         METEOROLOGY CONDITIONS USED TO PREDICT OVERALL MAXIMUM IMPACT
         ------------------------------------------------------------
                             YR MO DY JDY HR
                             -- -- -- --- --
                             10 01 10  10 01
  H0     U*     W*  DT/DZ ZICNV ZIMCH  M- O LEN    Z0  BOWEN ALBEDO  REF WS
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 -0.63  0.027  -9.000  0.020 - 999.   10.      2.9 0.250   0.40   0.17    0.50
                            HT  REF TA     HT
                          - - - - - - - - - - -
                            10.0   299.0    2.0
        METEOROLOGY CONDITIONS USED TO PREDICT AMBIENT BOUNDARY IMPACT
        ------------------------------------------------------------
```

```
                    YR MO DY JDY HR
                    -- -- -- --- --
                    10 01 10  10 01
  H0     U*     W*  DT/DZ ZICNV ZIMCH  M- O LEN    Z0  BOWEN ALBEDO  REF WS
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
-0.63  0.027 -9.000  0.020 - 999.   10.      2.9 0.250   0.40   0.17    0.50
                   HT  REF TA     HT
                  - - - - - - - - - - -
                  10.0   299.0    2.0
----------------------------------------------------------------------------
********************** AERSCREEN AUTOMATED DISTANCES *********************
              OVERALL MAXIMUM  CONCENTRATIONS  BY DISTANCE
----------------------------------------------------------------------------
```

MAXIMUM DIST (m)	MAXIMUM 1-HR CONC (ug/m3)	MAXIMUM DIST (m)	MAXIMUM 1-HR CONC (ug/m3)
1.00	8.800	2524.99	1.565
25.00	8.990	2550.00	1.552
50.01	9.180	2575.00	1.540
75.00	9.363	2600.00	1.527
100.00	9.541	2625.01	1.515
125.00	9.713	2650.00	1.503
150.01	9.880	2675.00	1.491
174.99	10.04	2700.00	1.480
200.00	10.20	2725.01	1.468
225.00	10.35	2749.99	1.457
250.00	10.51	2775.00	1.446
274.99	10.65	2800.00	1.435
300.00	10.80	2825.00	1.424
325.00	10.94	2849.99	1.415
350.00	11.07	2875.00	1.404
375.01	11.16	2900.00	1.394
400.00	11.28	2925.00	1.384
425.00	8.361	2950.01	1.374
450.00	7.399	2975.00	1.364
475.01	6.780	3000.00	1.355
500.00	6.250	3025.00	1.345
525.00	5.909	3050.01	1.336
550.00	5.620	3075.00	1.326
575.01	5.367	3100.00	1.317
599.99	5.145	3125.00	1.308
625.00	4.946	3150.00	1.300
650.00	4.767	3174.99	1.290
675.00	4.604	3200.00	1.281
699.99	4.456	3225.00	1.272
725.00	4.319	3250.00	1.264
750.00	4.193	3274.99	1.255
775.00	4.075	3300.00	1.246
800.01	3.966	3325.00	1.238
825.00	3.864	3350.00	1.230
850.00	3.769	3375.01	1.222
875.00	3.678	3400.00	1.214
900.01	3.593	3425.00	1.206
924.99	3.513	3450.00	1.198
950.00	3.437	3475.01	1.190
975.00	3.365	3499.99	1.182
1000.00	3.296	3525.00	1.175
1024.99	3.231	3550.00	1.168
1050.00	3.169	3575.00	1.160
1075.00	3.109	3599.99	1.153
1100.00	3.052	3625.00	1.146
1125.01	2.997	3650.00	1.139
1150.00	2.945	3675.00	1.132
1175.00	2.895	3700.01	1.125
1200.00	2.846	3725.00	1.118
1225.01	2.800	3750.00	1.111
1250.00	2.755	3775.00	1.105
1275.00	2.712	3800.01	1.098
1300.00	2.671	3825.00	1.091
1325.01	2.630	3850.00	1.085

1349.99	2.592	3875.00	1.079
1375.00	2.554	3900.00	1.072
1400.00	2.518	3924.99	1.066
1425.00	2.483	3950.00	1.060
1449.99	2.449	3975.00	1.054
1475.00	2.416	4000.00	1.048
1500.00	2.384	4024.99	1.042
1525.00	2.352	4050.00	1.036
1550.01	2.321	4075.00	1.030
1575.00	2.292	4100.00	1.025
1600.00	2.264	4125.01	1.019
1625.00	2.236	4150.00	1.014
1650.01	2.209	4175.00	1.008
1674.99	2.182	4200.00	1.003
1700.00	2.157	4225.01	0.9972
1725.00	2.132	4249.99	0.9918
1750.00	2.107	4275.00	0.9865
1774.99	2.084	4300.00	0.9813
1800.00	2.060	4325.00	0.9761
1825.00	2.038	4349.99	0.9710
1850.00	2.016	4375.00	0.9659
1875.01	1.994	4400.00	0.9608
1900.00	1.973	4425.00	0.9558
1925.00	1.952	4450.01	0.9509
1950.00	1.932	4475.00	0.9460
1975.01	1.912	4500.00	0.9411
1999.99	1.893	4525.00	0.9363
2025.00	1.874	4550.01	0.9316
2050.00	1.856	4575.00	0.9269
2075.00	1.837	4600.00	0.9222
2099.99	1.820	4625 .00	0.9176
2125.00	1.802	4650.00	0.9130
2150.00	1.785	4674.99	0.9085
2175.00	1.769	4700.00	0.9040
2199.99	1.752	4725.00	0.8996
2225.00	1.736	4750.00	0.8951
2250.00	1.720	4774.99	0.8907
2275.00	1.705	4800.00	0.8864
2300.01	1.690	4825.00	0.8821
2325.00	1.675	4850.00	0.8779
2350.00	1.660	4875.01	0.8737
2375.00	1.646	4900.00	0.8695
2400.01	1.632	4925.00	0.8654
2424.99	1.618	4950.00	0.8612
2450.00	1.604	4975.01	0.857 2
2475.00	1.591	4999.99	0.8532
2500.00	1.578		

********************* AERSCREEN MAXIMUM IMPACT SUMMARY ********************

3-hour, 8-hour, and 24-hour scaled
concentrations are equal to the 1-hour concentration as referenced in
SCREENING PROCEDURES FOR ESTIMATING THE AIR QUALITY
IMPACT OF STATIONARY SOURCES, REVISED (Section 4.5.4)
Report number EPA-454/R-92-019
http://www.epa.gov/scram001/guidance_permit.htm
under Screening Guidance

CALCULATION PROCEDURE	MAXIMUM 1-HOUR CONC (ug/m3)	SCALED 3-HOUR CONC (ug/m3)	SCALED 8-HOUR CONC (ug/m3)	SCALED 24-HOUR CONC (ug/m3)	SCALED ANNUAL CONC (ug/m3)
FLAT TERRAIN	11.29	11.29	11.29	11.29	N/A
DISTANCE FROM SOURCE 402.00 meters					
IMPACT AT THE AMBIENT BOUNDARY	8.800	8.800	8.800	8.800	N/A
DISTANCE FROM SOURCE 1.00 meters					

Appendix J
Spray Drift Deposition Curves

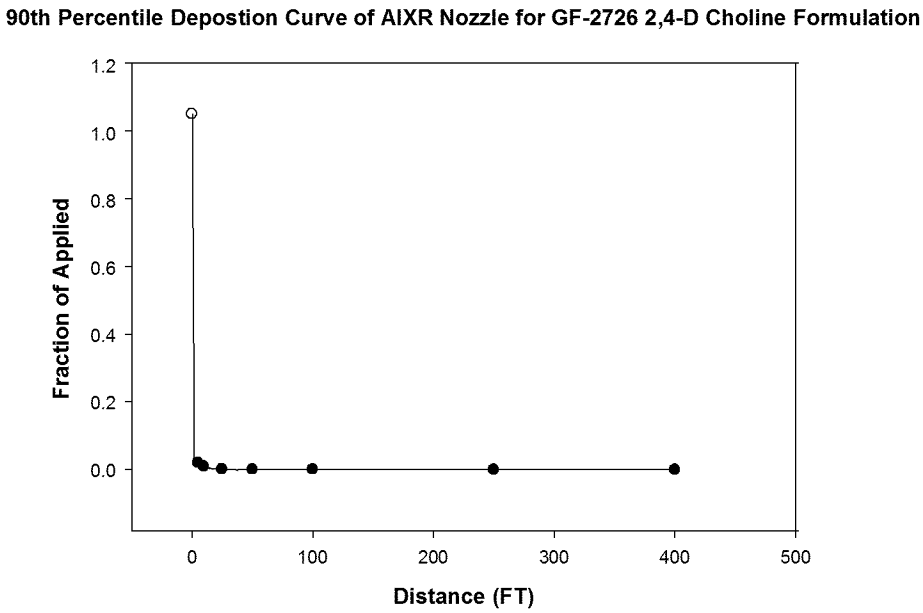


Figure J-1

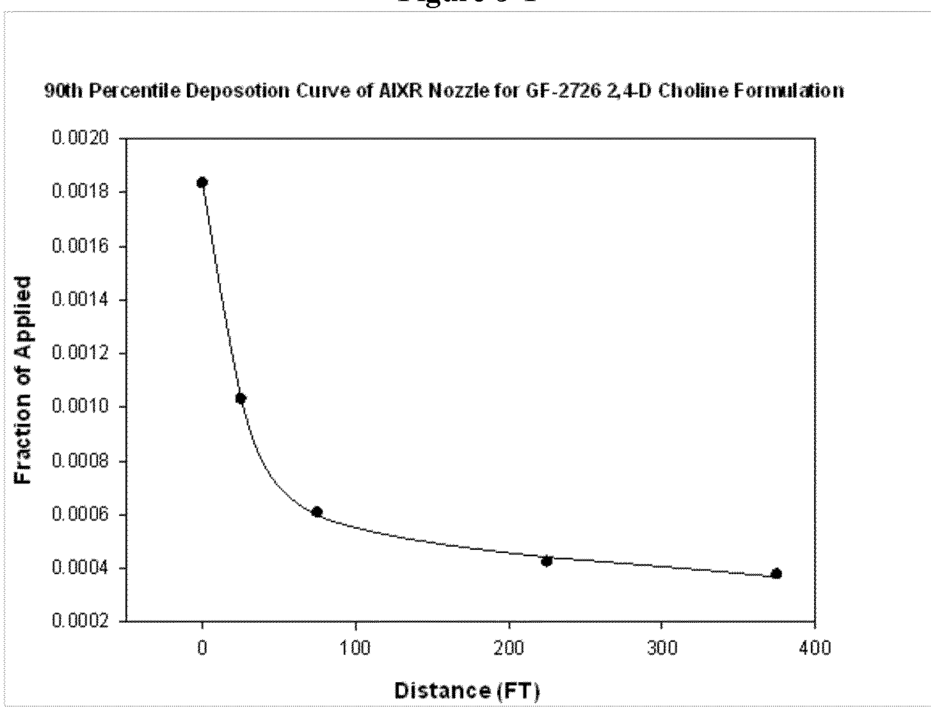


Figure J-2

ED_Vaughn3_0000634